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Efficacy of Sugar Substitutes in Reducing Dental Caries in Children: A Systematic Review

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Abstract

Objectives: This systematic review aims to evaluate the existing scientific evidence on the effectiveness of sugar substitutes in preventing dental caries in children. **Methods:** We conducted a systematic search of electronic databases like PubMed, MEDLINE, Science Direct, and Scopus. Two independent reviewers screened and extracted data from eligible studies. **Results:** Nine studies included 2006 children in total and their ages ranged from 3 to 15 years. The reported follow-up duration mentioned in these RCTs ranged from 1 month to 36 months. Xylitol has antimicrobial activity, has a positive effect on salivary profile values, and efficiently reduces the risk of caries in either the short or long term in primary or permanent teeth. Three studies investigated xylitol and erythritol; one reported that the erythritol group showed fewer teeth and surfaces with dentin caries than the xylitol group, one reported that there was no difference between the two substances after 3 years of application, and the other found that lollipops that contain xylitol and erythritol have the ability to raise salivary pH and prevent it from falling below the necessary level. **Conclusion:** In children and teenagers, the use of xylitol or erythritol as sugar substitutes may be beneficial in avoiding caries in permanent teeth. Using xylitol is just one component of the caries prevention jigsaw, anyway. It is necessary to do more comparison studies with longer follow-up times.

Keywords: Dental caries, Children, Sugar substitutes, Xylitol, Sorbitol, Caries prevention

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Introduction

Dental caries, commonly known as tooth decay, is a prevalent oral health issue that affects a large number of children worldwide. It is primarily caused by the buildup of plaque, which is a sticky film of bacteria that forms on the teeth. When sugary foods and beverages are consumed, the bacteria in plaque produce acid that attacks the enamel, leading to the development of cavities. As a result, the reduction of sugar intake has long been recognized as an important preventive measure against dental caries [1].

In recent years, sugar substitutes have gained popularity as an alternative to sugar for sweetening foods and beverages. These substances mimic the taste of sugar while providing fewer calories and not contributing to the formation of cavities. As such, sugar substitutes have been the subject of numerous studies investigating their efficacy in reducing dental caries in children [2].

One of the most widely used sugar substitutes is xylitol, a natural sweetener found in many fruits and vegetables. Various studies have demonstrated the caries-preventive effects of xylitol, particularly when used in chewing gum or lozenges. Xylitol works by inhibiting the growth of bacteria in the mouth, including

Streptococcus mutans, the primary bacteria responsible for tooth decay. By reducing the levels of these harmful bacteria, xylitol helps to maintain a healthy oral environment and prevent the development of cavities [3].

Another popular sugar substitute is erythritol, a sugar alcohol that is both low in calories and non-cariogenic, meaning it does not promote the formation of cavities. Studies have shown that erythritol can effectively reduce the levels of acid-producing bacteria in the mouth and inhibit the demineralization of enamel. Additionally, erythritol has been found to have a cooling effect on the mouth, making it a refreshing option for individuals seeking to reduce their sugar intake [4].

Stevia, a natural sweetener derived from the leaves of the Stevia rebaudiana plant, is another sugar substitute that has been extensively studied for its potential dental benefits. Research has shown that stevia can help to suppress the growth of oral bacteria and reduce the formation of plaque. Furthermore, stevia has been found to have anti-inflammatory properties that can help to protect the gums and prevent periodontal disease, a common complication of untreated dental caries [5].

While the use of sugar substitutes shows promise in reducing dental caries in children, it is important to note that these substances should be used in conjunction with other preventive measures, such as regular brushing and flossing, and routine dental checkups. Additionally, parents should be mindful of the potential side effects of sugar substitutes, such as gastrointestinal distress, and monitor their children's intake accordingly [6].

Dental caries is a significant health problem in children worldwide. Sugary foods and drinks are a major contributing factor. Sugar substitutes offer a potential alternative to reduce caries risk. This study aims to evaluate the existing scientific evidence on the effectiveness of sugar substitutes in preventing cavities in children. Despite existing preventive measures like fluoridated toothpaste, dental caries remain a prevalent childhood health issue. Understanding the effectiveness of sugar substitutes can provide valuable insights for developing additional strategies to combat childhood cavities. This systematic review aims to comprehensively assess the current research on the efficacy of sugar substitutes in reducing dental caries in children.

Study Objectives:

- To systematically identify and critically appraise all relevant studies on the use of sugar substitutes for caries prevention in children.
- To assess the overall effect size of sugar substitutes on caries reduction in children.
- To investigate the effectiveness of different types of sugar substitutes (e.g., xylitol, sorbitol) for caries prevention.
- To evaluate the influence of dosage and delivery methods of sugar substitutes on their effectiveness.

Methods

To ensure a rigorous and transparent review process, this study followed the established Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [7]. We conducted a systematic search of electronic databases, including PubMed, Web of Science, SCOPUS, and Science Direct. The search strategy targeted English-language studies that investigate the effectiveness of sugar substitutes in preventing dental caries in children. We employed relevant keywords related to sugar substitutes, dental caries, and children to capture pertinent research. Two independent reviewers then screened the identified studies, selected studies meeting the eligibility criteria, extracted data, and critically appraised the methodological quality of the included studies using established tools.

Eligibility Criteria

Inclusion criteria:

1. Studies that investigate the relationship between sugar substitute consumption and dental caries in children.
2. Studies that include children as the primary population group.
3. Studies that are published in the English language.
4. Studies that have a clear definition of sugar substitutes and dental caries.
5. Studies conducted within the last ten years (2014-2024).
6. Studies published in peer-reviewed journals.

Exclusion criteria:

7. Studies that do not focus on the relationship between sugar substitute consumption and dental caries in children.
8. Studies that do not include children as the primary population group.
9. Studies that are not published in the English language.
10. Studies that have unclear definitions of sugar substitutes and dental caries.
11. Studies that are not published in peer-reviewed journals.

Data Extraction

To ensure accuracy and consistency in the selection process, titles and abstracts retrieved from the electronic search were uploaded to Rayyan (QCRI) [8] software for initial screening. Two independent reviewers assessed the retrieved titles and abstracts against the predefined inclusion and exclusion criteria. Studies deemed relevant underwent full-text review by both reviewers. Any discrepancies in selection were resolved through discussion and consensus.

Following a full-text review, a standardized data extraction form was used to capture key study characteristics, including title, authors, publication year, study location, participant demographics (age & gender), intervention type (specific sugar substitute used), and caries outcomes. Additionally, a tool specifically designed to evaluate methodological quality were employed to assess the risk of bias within the included studies.

Data Synthesis Strategy

Following data extraction, we conducted a qualitative synthesis of the findings from the included studies. This involved creating summary tables that organize key information extracted from the research, such as study characteristics, interventions (types of sugar substitutes used), and reported outcomes related to dental caries in children. Once the data synthesis was complete, we determined the most appropriate method for interpreting data from the included studies.

Risk of Bias Assessment

The Cochrane Collaboration Risk of Bias (ROB) tool [9] was used to assess the risk of bias in the included randomized control trials. The results are shown in a table with different color schemes. Red denotes a large bias risk, green denotes a low risk, and yellow denotes an inability to determine the risk due to insufficient information.

Results

Search results

A thorough search turned up 1019 study papers in total after 509 duplicates were eliminated. 422 papers were rejected after 510 studies' titles and abstracts were assessed. Out of the 88 reports that needed to be obtained, three items could not be found. A total of 85 papers underwent screening for full-text assessment; of these, 61 were rejected due to incorrect study results, 12 due to improper population type, 1 article being

an editor's letter, and 2 being abstracts. In this systematic review, nine research publications met the eligibility standards. An overview of the procedure used to choose the research is illustrated in **Figure 1.**

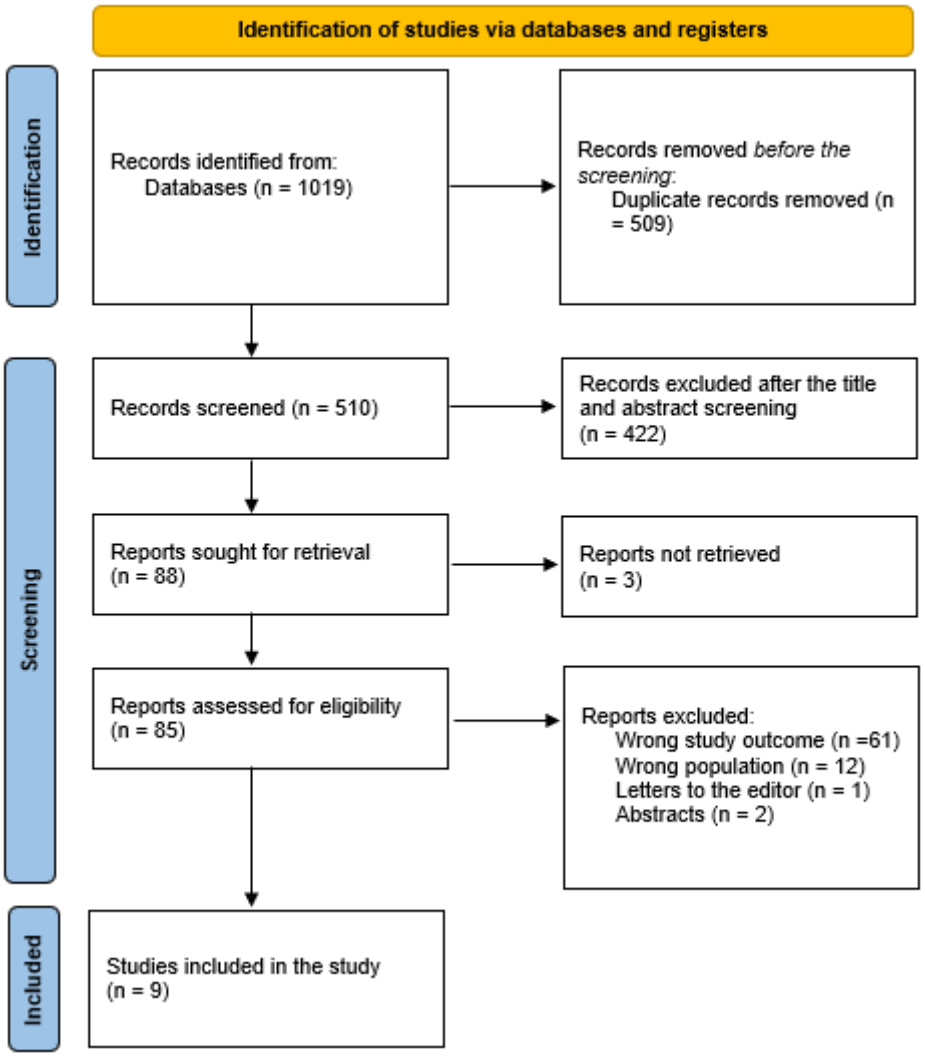

Figure (1): Study decision is summed up in a PRISMA diagram.

Sociodemographic features of the comprised studies

The research publications' sociodemographic information is displayed in **Table 1.** Nine studies included 2006 children in total and their ages ranged from 3 to 15 years. Eight of the included studies were RCTs [10, 11, 13-18] and one was a randomized uncontrolled trial [12]. Three studies were conducted in India [10, 11, 13], two in Peru [12, 14], two in Estonia [15, 16], and two in the USA [17, 18].

Clinical outcomes

The clinical features are displayed in **Table (2)**. The reported follow-up duration mentioned in these RCTs ranged from 1 month to 36 months. Six studies investigated the efficacy of xylitol in preventing dental caries in children. It has antimicrobial activity [11, 13], has a positive effect on salivary profile values (salivary volume, salivary flow, salivary pH, buffering capacity, and fluoride concentration) [12], and efficiently reduces the risk of caries in either the short or long term in primary or permanent teeth [14, 17, 18]. Three studies investigated xylitol and erythritol; one reported that the erythritol group showed fewer teeth and surfaces with dentin caries than the xylitol group [16], one reported that there was no difference between the two substances after 3 years of application [15], and the other found that lollipops that contain xylitol and erythritol have the ability to raise salivary pH and prevent it from falling below the necessary level [10].

.**Table (1): The sociodemographic attributes of the participating populations.**

Study	Study design	Country	Participants	Mean age/ range	Females (%)
Jain & Mathur, 2022 [10]	RCT	India	50	3 - 6	NM
Krupa et al., 2022 [11]	RCT	India	30	5 - 12	NM
Aguirre-Aguilar et al., 2022 [12]	Randomized uncontrolled clinical trial	Peru	96	5	NM
Aluckal et al., 2018 [13]	RCT	India	60	12 - 15	20 (33.3%)
Chi et al., 2016 [14]	RCT	Peru	153	7.2 ± 2	68 (44.4%)
Falony et al., 2016 [15]	RCT	Estonia	485	NM	NM
Honkala et al., 2014 [16]	RCT	Estonia	485	8.7	NM
Chi et al., 2014 [17]	RCT	USA	85	5.5 (0.61)	44 (51.8)
Gold, 2016 [18]	RCT	USA	562	5 - 6	NM

Table (2): Clinical features and results of the included research.

Study	Follow-up (months)	Intervention (substance used)	Main outcomes
Jain & Mathur, 2022 [10]	NM	Xylitol and erythritol	Small children can consume lollipops that contain xylitol and erythritol since they have the ability to raise salivary pH and prevent it from falling below the necessary level.
Krupa et al., 2022 [11]	NM	Xylitol	The antimicrobial activity of mouth rinses containing xylitol and probiotics was shown to be similar to that of chlorhexidine in children.

Aguirre-Aguilar et al., 2022 [12]	3	Xylitol	In caries-free 5-year-old children with varying Oral Hygiene Index, the Open House Initiative levels, applying Xeros Dentaid® oral moisturizer twice a day, composed of xylitol and malic acid, has a positive effect on salivary profile values (salivary volume, salivary flow, salivary pH, buffering capacity, and fluoride concentration).
Aluckal et al., 2018 [13]	1	Xylitol	Comparing xylitol gum to polyol gum and the control group, the former has demonstrated the greatest efficacy against salivary S. mutans.
Chi et al., 2016 [14]	9	Xylitol	Milk that has been sweetened with xylitol may be a viable way to stop tooth decay in areas where milk is sweetened.
Falony et al., 2016 [15]	NM	Xylitol and erythritol	After three years of regular consumption of erythritol-containing candies in comparison with xylitol and control candies, the differences in terms of decreased increment of decayed, missing, and filled teeth and surfaces in children with a combination of teeth were no longer observed three years later.
Honkala et al., 2014 [16]	36	Xylitol and erythritol	During the follow-up exams, the erythritol group showed fewer teeth and surfaces with dentin caries than the xylitol or control groups. In the erythritol group, the time it took for caries lesions to develop was the longest.
Chi et al., 2014 [17]	NM	Xylitol	Brushing with a low-strength xylitol/fluoride toothpaste is no more effective than using fluoride-only toothpaste after six months in a kid group with a high caries risk for preventing early childhood caries.
Gold, 2016 [18]	30	Xylitol	For nine months, eating xylitol gummy bears throughout the school day did not reduce the risk of caries in either the short or long term in primary or permanent teeth.

*NA=Not-applicable

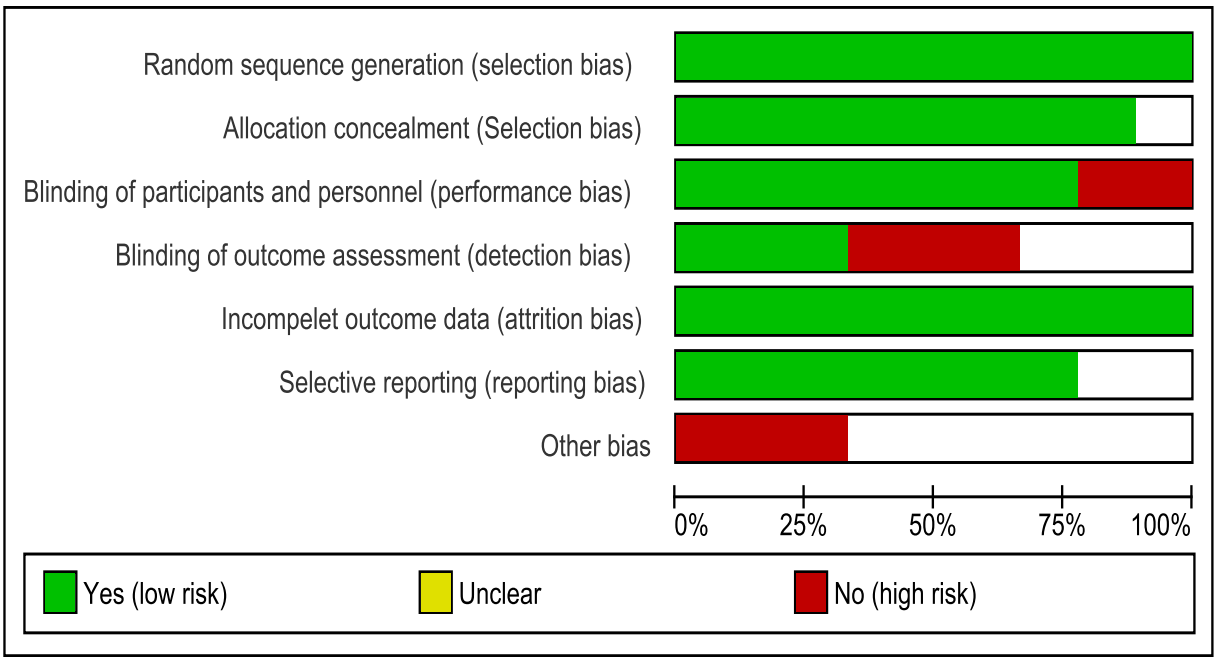

Figure (2): Risk of bias graph.

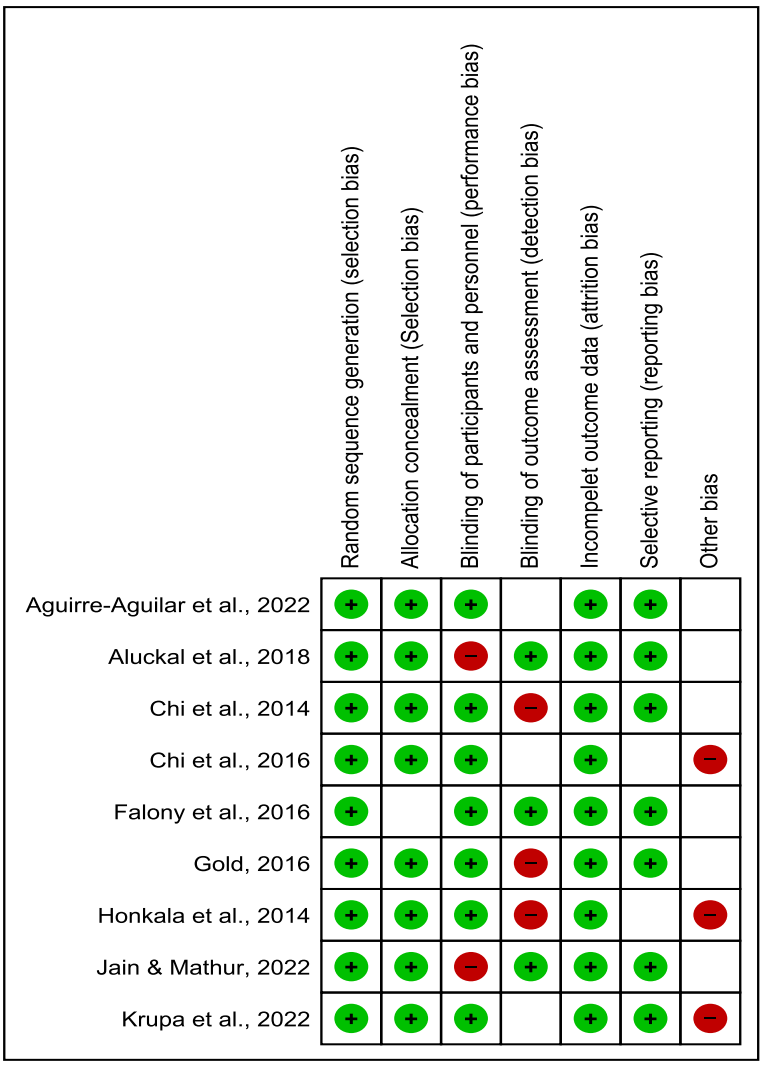

Figure (3): Risk of bias summary.

Discussion

This assessment of xylitol's potential impact on reducing dental caries in kids is crucial because inconsistent findings from clinical trials and even literature reviews have been reported. Although there are still disagreements and unanswered problems about xylitol's usefulness in lowering the prevalence of dental caries, published clinical guidelines frequently include recommendations for xylitol use for caries prevention in persons [19]. This review found that xylitol has antimicrobial activity [11, 13], has a positive effect on salivary profile values (salivary volume, salivary flow, salivary pH, buffering capacity, and fluoride concentration) [12], and efficiently reduces the risk of caries in either the short or long term in primary or permanent teeth [14, 17, 18]. Similarly, **Riley *et al.*** reported that when it comes to preventing caries in children's permanent teeth, fluoride toothpaste with xylitol may be more successful than fluoride-only toothpaste, and this toothpaste does not have any negative side effects [20]. **Pienihäkkinen *et al.*** also reported that in children with high or moderate caries levels at the study baseline, the caries-reducing benefit of including xylitol chewing gum into the daily diet has been well-demonstrated. On smooth tooth surfaces, individuals with active, incipient caries lesions may benefit from using xylitol gum [21].

Chewing and the sweet taste of xylitol, which is found in chewing gum, both encourage salivary flow. Because of this quality, saliva has a higher capacity to act as a buffer, which helps ward off tooth decay [22].

However, the mechanical stimulus of chewing may be more essential than xylitol use in preventing tooth decay, according to **Machiulskiene *et al.*** [23]. Another theory suggests that xylitol may have an impact on the de-remineralization process. According to this process, the hydrophilic xylitol molecule can combine with salivary calcium to create complexes that stabilize the oral environment's calcium phosphate systems [24]. By delivering this ion, salivary calcium saturation encourages a propensity to remineralize dental tissues and regulates the disintegration of calcified tissues, including teeth [25].

Xylitol and erythritol were the subject of three studies in this review; the first found that the erythritol group had fewer teeth and dentin caries surfaces than the xylitol group [16], the second found that after three years of application, there was no difference between the two substances [15], and the third found that lollipops containing both xylitol and erythritol could raise salivary pH and keep it from falling below the required level [10]. To get a firm conclusion, further carefully planned clinical trials are required.

Thus, to enable short-term clinical investigations and better control of confounders, future research on xylitol, polyols, and other preventative interventions should include the selection of high-risk participants and, preferably, the use of certain particular diagnostic instruments (such as laser fluorescence). Then, different preventative actions could be much more directly linked to the advancement or cessation of active caries lesions than can be accomplished in multi-year clinical trials. A placebo control is necessary when researching, for example, the effects of polyols specifically, but the no-intervention arm should also be included in the study setting in order to assess the clinical importance of the results. We believe that it is crucial to first demonstrate the existence of the preventative impact. When the subjects at the research baseline had at least a moderate risk of developing caries, the effect of any preventative treatment (including xylitol) can be identified. Second, the preventive measure's clinical and practical usefulness should be assessed based on many factors, such as the kind of preventive measure, the degree of its preventive effect, its mode of action, and any related costs or negative consequences. The population's caries prevalence and each patient's unique caries risk are major determinants of the practical value. It is not always possible to extrapolate data from people with high or moderate caries levels to populations with lower caries levels.

Conclusion

In children and teenagers, the use of xylitol or erythritol as sugar substitutes may be beneficial in avoiding caries in permanent teeth. Using xylitol is just one component of the caries prevention jigsaw, anyway. It is necessary to do more comparison studies with longer follow-up times.

References:

1. Gupta P, Gupta N, Pawar AP, Birajdar SS, Natt AS, Singh HP. Role of sugar and sugar substitutes in dental caries: a review. ISRN Dent. 2013;2013:519421. Published 2013 Dec 29. doi:10.1155/2013/519421
2. Kidd EAM, Fejerskov O. *Dental Caries—the Disease and Its Clinical Management*. John Wiley & Sons; 2008.
3. Lim S, Sohn W, Burt BA, et al. Cariogenicity of soft drinks, milk and fruit juice in low-income African-American children: a longitudinal study. *Journal of the American Dental Association*. 2008;139(7):959–967.
4. Gupta M. Sugar Substitutes: Mechanism, Availability, Current Use and Safety Concerns-An Update. Open Access Maced J Med Sci. 2018;6(10):1888-1894. Published 2018 Oct 19. doi:10.3889/oamjms.2018.336
5. Liang NL, Luo BW, Sun IG, Chu CH, Duangthip D. Clinical Effects of Sugar Substitutes on Cariogenic Bacteria: A Systematic Review and Meta-Analysis. Int Dent J. Published online April 9, 2024. doi:10.1016/j.identj.2024.02.008
6. Gardana C, Scaglianti M, Simonetti P. Evaluation of steviol and its glycosides in Stevia rebaudianaleaves and commercial sweetener by ultra-high-performance liquid chromatography- massspectrometry. J Chromatogr A. 2010;1217(9):1463–1470. https://doi.org/10.1016/j.chroma.2009.12.036 PMid:20102764.
7. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. International journal of surgery. 2021 Apr 1;88:105906.

8. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. Systematic reviews. 2016 Dec;5:1-0.
9. Higgins JP, Savović J, Page MJ, Elbers RG, Sterne JA. Assessing risk of bias in a randomized trial. Cochrane handbook for systematic reviews of interventions. 2019 Sep 23:205-28.
10. Jain S, Mathur S. Estimating the effectiveness of lollipops containing xylitol and erythritol on salivary pH in 3–6 years olds: A randomized controlled trial. Journal of Indian Society of Pedodontics and Preventive Dentistry. 2022 Jan 1;40(1):19-22.
11. Krupa NC, Thippeswamy HM, Chandrashekar BR. Antimicrobial efficacy of Xylitol, Probiotic and Chlorhexidine mouth rinses among children and elderly population at high risk for dental caries–A Randomized Controlled Trial. Journal of Preventive Medicine and Hygiene. 2022 Jun;63(2):E282.
12. Aguirre-Aguilar AA, Delgado-Asmat EE, Ríos-Caro TE, Aguirre-Aguilar AA, Coronel-Zubiate FT. Effectiveness of an Oral Moisturizer with Malic Acid/Xylitol as Anti-caries Therapy in Children. Universitas Medica. 2022 Apr;63(2):2.
13. Aluckal E, Ankola AV. Effectiveness of xylitol and polyol chewing gum on salivary streptococcus mutans in children: A randomized controlled trial. Indian Journal of Dental Research. 2018 Jul 1;29(4):445-9.
14. Chi DL, Zegarra G, Vasquez Huerta EC, Castillo JL, Milgrom P, Roberts MC, Cabrera-Matta AR, Merino AP. Milk sweetened with xylitol: a proof-of-principle caries prevention randomized clinical trial. Journal of Dentistry for Children. 2016 Sep 15;83(3):152-60.
15. Falony G, Honkala S, Runnel R, Olak J, Nõmmela R, Russak S, Saag M, Mäkinen PL, Mäkinen K, Vahlberg T, Honkala E. Long-term effect of erythritol on dental caries development during childhood: a posttreatment survival analysis. Caries Research. 2016 Nov 3;50(6):579-88.
16. Honkala S, Runnel R, Saag M, Olak J, Nõmmela R, Russak S, Mäkinen PL, Vahlberg T, Falony G, Mäkinen K, Honkala E. Effect of erythritol and xylitol on dental caries prevention in children. Caries research. 2014 May 21;48(5):482-90.
17. Chi DL, Tut O, Milgrom P. Cluster-randomized xylitol toothpaste trial for early childhood caries prevention. Journal of dentistry for children. 2014 Mar 15;81(1):27-32.
18. Gold J. Consumption of xylitol gummy bears may not provide additional caries prevention for school children. Journal of Evidence Based Dental Practice. 2016 Mar 1;16(1):70-2.
19. American Academy of Pediatric Dentistry. Guidelines on xylitol use in caries prevention. Pediatr Dent 2015;36 (special issue):175-8.
20. Riley P, Moore D, Ahmed F, Sharif MO, Worthington HV. Xylitol-containing products for preventing dental caries in children and adults. Cochrane database of systematic reviews. 2015(3).
21. Pienihäkkinen K, Hietala-Lenkkeri A, Arpalahti I, Söderling E. The effect of xylitol chewing gums and candies on caries occurrence in children: a systematic review with special reference to caries level at study baseline. European Archives of Paediatric Dentistry. 2024 Apr;25(2):145-60.
22. Ribelles Llop M, Guinot Jimeno F, Mayné Acién R, Bellet Dalmau LJ. Effects of xylitol chewing gum on salivary flow rate, pH, buffering capacity and presence of Streptococcus mutans in saliva Eur J Paediatr Dent. 2010;11:9–14
23. Machiulskiene V, Nyvad B, Baelum V. Caries preventive effect of sugar-substituted chewing gum Community Dent Oral Epidemiol. 2001;29:278–88
24. Cardoso CA, Cassiano LP, Costa EN, et al Effect of xylitol varnishes on remineralization of artificial enamel caries lesions in situ J Dent. 2016;50:74–8.
25. Mäkinen KK, Söderling E. Solubility of calcium salts, enamel, and hydroxyapatite in aqueous solutions of simple carbohydrates Calcif Tissue Int. 1984;36:64–71.