International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 24s, 2025
https://theaspd.com/index.php

Effectiveness Of Chewing Gum In Dental Hygiene: A Systematic Review Of Clinical Trials

Keshav,[1]Pramod Kumar[1], Shrimohan Shrivastava[2], Apoorv Mishra[3], Dheeraj Upadhyay[4],Swarnakshi Upadhyay[1*]
[1]School of Pharmaceutical Sciences, CSJM University, Kanpur- 208024, India
[2]Advance Institute of Biotech and Paramedical Sciences, Kanpur- 209217, India
[3]Samahi College of Pharmacy,Dibiyapur- 206244, India
[4]Sainik Pharmacy College, Hanumanganj Prayagraj- 221505

Abstract

Background: *Oral diseases remain a major global public health concern, disproportionately affecting vulnerable populations. While toothbrushing and flossing are recognized as foundational practices for maintaining oral hygiene, compliance is often limited by behavioral, physical, and socioeconomic factors. Consequently, there is growing interest in adjunctive approaches such as therapeutic chewing gums to enhance oral health outcomes.*

Objective: *This systematic review evaluates the clinical effectiveness of chewing gum, particularly formulations containing xylitol, fluoride, or other functional agents, in reducing dental plaque, preventing caries, modulating oral microbiota, stimulating salivary flow, and improving oral pH buffering.*

Methods: *Following PRISMA 2020 guidelines, a comprehensive literature search was conducted across PubMed, Scopus, and Web of Science for studies published between January 2000 and December 2024. Randomized controlled trials (RCTs), controlled clinical trials (CCTs), and quasi-experimental studies involving chewing gum as an intervention were included. Data extraction and risk of bias assessment were independently performed by two reviewers. Outcomes analyzed included plaque index scores, caries incidence, microbial changes, salivary flow rate, and secondary benefits such as xerostomia relief.*

Results: *Thirty clinical trials met the inclusion criteria. Xylitol gum demonstrated the most consistent benefits, showing significant reductions in Streptococcus mutans levels, plaque indices (up to 38%), and caries incidence (up to 70%). Fluoride gums primarily contributed to enamel remineralization, while sorbitol and placebo gums exhibited limited antimicrobial effects. Chewing gum was also associated with increased salivary flow (up to 1.8 mL/min) and improved oral pH buffering. Secondary outcomes included subjective improvements in breath freshness and dry mouth symptoms.*

Conclusion: *Chewing gum, particularly xylitol-based formulations, can serve as an effective adjunct to conventional oral hygiene practices. Its benefits are especially relevant in pediatric and high-caries-risk populations. Further large-scale, standardized clinical trials are warranted to strengthen the evidence base and inform public health recommendations.*

Keywords: *Xylitol, Dental caries, Chewing gum, Oral hygiene, Salivary stimulation, Streptococcus mutans, Dental plaque*

1. INTRODUCTION

1.1 Global Burden of Dental Diseases

A really big problem that affects global health right now are issues around dental health. There are approximately three and a half billion people around the world who suffer from problems with their teeth and gums and that's according to the WHO [1]. Among these conditions, dental caries stands out as the most widespread, with an estimated 2.3 billion people suffering from decay in permanent teeth and over 530 million children affected in their primary dentition [2]. Periodontal diseases are a major contributor to the global health burden and especially among older people. Period health is also closely linked to diabetes and heart problems too. Despite all the progress in making people aware of oral health and educating them about it, there are still significant differences between different economic groups, across different regions and among varying age groups who get to benefit from those lessons. So barriers to dental treatment are huge—high costs, not much access to good dental care from professionals and people who need to take better care of their oral

health by brushing and flossing a lot. This is definitely a harder thing in poorer countries [3], places where healthcare resources can sometimes be lacking.

1.2 Limitations of Conventional Oral Hygiene Practices

The use of fluoride toothpaste during toothbrushing, along with regular flossing, is widely endorsed as the cornerstone of daily oral hygiene. Still it's true that adherence to guidelines and tips is often poor, which can be down to various different obstacles including low motivation, heavy time pressures, poor dexterity of hands, or lack of awareness. This lack of adherence may especially happen among kids, the elderly folks and people who suffer from physical or cognitive problems [4]. Even among populations with adequate access to dental care resources, challenges such as poor technique, irregular application, and insufficient plaque control remain prevalent. Flossing, while particularly effective in disrupting plaque between adjacent teeth, is commonly underused due to its perceived difficulty and inconvenience[5]. Given these limitations researchers and dental pros have also been branching out into new strategies that are one part simple, another part easy to fit into different cultures and which together also work really well to reinforce regular brushing and flossing[6].

1.3 Chewing Gum as an Adjunctive Tool

While chewing gum used to be a treat just for fun and minty freshness in the mouth, today it has gotten more serious[7]. It's becoming seen not just as a treat, but also as a useful help to regular brushing and cleaning for teeth and gums. When sugar-free and fortified with therapeutic agents such as xylitol, sorbitol, or fluoride, chewing gum may contribute both mechanical and biochemical benefits to oral health[8]. Xylitol, a naturally occurring polyol, has been widely studied for its anticariogenic properties, particularly its capacity to inhibit the growth and adhesion of Streptococcus mutans, a major pathogen implicated in the development of dental caries [9]. Fluoride chewing gums also stimulate mineralization of enamel and improve the resistance against acid erosion processes, according to studies [10]. Beyond its chemical composition, the chewing action itself enhances salivary secretion, which assists in flushing away residual food particles and microbial biofilm. Additionally, increased salivary flow improves acid buffering capacity, helping to maintain a neutral pH and promote a healthier oral environment [11].

1.4 Biological Rationale and Mechanism of Action

Salivary Stimulation: The act of mastication activates mechanoreceptors in the oral musculature, which, in turn, stimulates increased salivary flow. Saliva acts as wonderful rinse fluid - it dilutes sugars and acids and also helps the whole mouth clean itself naturally and nicely. Acid Buffering: Stimulated saliva contains elevated concentrations of bicarbonate, enhancing its ability to neutralize acids [12]. This buffering capacity is critical in mitigating acid attacks from cariogenic bacteria and preventing the demineralization of enamel. Antimicrobial Action: Sugar-free chewing gums, particularly those formulated with xylitol or mannitol, have been shown to inhibit the proliferation and adherence of cariogenic microorganisms such as Streptococcus mutans and Lactobacillus species—both key contributors to dental caries [13]. Enamel Remineralization: Some specialized gum formulations are designed to release fluoride, calcium, or phosphate ions during chewing. These ions help to rebuild early lesions in enamel and promoting taking of minerals into areas which need building up [14].

Together, they picture chewing gum not only as a great helper for regular dental care routine but also as a super low-cost way to promote health for everybody. This is especially important for underserved communities where access to professional dental care might be pretty rare**.**

1.5 Rationale for a Systematic Review

Over the past two decades, a substantial number of randomized controlled trials (RCTs) and clinical investigations have explored the impact of chewing gum on diverse aspects of oral health. However, the resulting results are still mixed and there is significant variability when it comes to study methods. Differences in participant populations, gum formulations (e.g., xylitol-, fluoride-, or sorbitol-based), duration and frequency of gum use, and selected outcome measures have all contributed to the variability in reported findings [15]. While some studies do show pretty dramatic results showing people reduce a lot of plaque in their teeth and also have less cavities, we've also seen other studies showing less difference or where plaque

and cavities stayed about same for people even after supposedly new techniques or products. This inconsistency highlights the need for a thorough and structured evaluation of the available evidence. A systematic review is well-positioned to address this gap by aggregating data from multiple rigorous studies, discerning overarching trends, critically assessing methodological quality, and offering evidence-based guidance regarding the utility of chewing gum as a preventive tool in oral hygiene [16].

1.6 Objectives and Research Questions

The primary aim of this systematic review is to assess the clinical efficacy of chewing gum as an adjunctive strategy for enhancing oral hygiene and preventing dental diseases, based on evidence derived from controlled clinical trials[17]. Asking essential questions are at the heart of this review RQ1: Does the use of chewing gum result in a statistically significant reduction in dental plaque compared to either no intervention or the use of placebo gum? RQ2: Is there evidence to suggest that chewing gum can lower the incidence and severity of dental caries over time? RQ3: How does chewing gum influence salivary parameters, such as flow rate, buffering capacity, and the composition of the oral microbiota? RQ4: Do specific chewing gum formulations—such as those containing xylitol, fluoride, or other active agents—demonstrate superior clinical outcomes? Through exploring these important questions closely, this review is aiming to really piece together some insights that are really useful for practitioners who provide dental care and researchers who dig deep into tooth health, and senior public health advisors who want accessible, fun stuff that really nudge patients into good oral health habits that last day after day [18].

2. METHODOLOGY

2.1 Study Design and Protocol Registration

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, ensuring a transparent and reproducible methodological approach . The review protocol was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO) under the registration number CRD42025294589. To enhance the reliability and objectivity of the findings, all stages of the review process—including literature search, eligibility screening, data extraction, and quality appraisal—were independently undertaken by two reviewers. Any problems were clarified through discussion or by calling in another reviewer as a way to really minimize any potential for favouritism .

2.2 Eligibility Criteria

Studies were selected based on predefined inclusion and exclusion criteria using the PICOS (Population, Intervention, Comparator, Outcomes, Study Design**)** framework:

Element	Criteria
Population	Humans of all age groups, with or without diagnosed dental diseases. No restriction on gender, location, or socioeconomic status.
Intervention	Use of chewing gum, either sugar-free or therapeutic (e.g., xylitol, fluoride, sorbitol), as a standalone or adjunct to daily oral hygiene.
Comparator	No chewing gum, placebo chewing gum, or standard care (e.g., brushing/flossing only).
Outcomes	At least one of the following: (1) Plaque index scores; (2) Caries incidence or DMFT index; (3) Salivary pH or flow rate; (4) Oral microbiota changes; (5) Other secondary oral health benefits.
Study Design	Randomized Controlled Trials (RCTs), Controlled Clinical Trials (CCTs), or quasi-experimental designs.

Exclusion Criteria:

Observational studies without control groups.

Case reports, editorials, and reviews.
In vitro or animal studies.

- Studies not reporting clinical oral health outcomes.

2.3 Information Sources and Search Strategy

A comprehensive literature search was undertaken across multiple electronic databases, including PubMed (MEDLINE), Scopus, and Web of Science (WoS), to identify relevant clinical studies examining the effectiveness of chewing gum in dental hygiene. The search spanned publications from January 1, 2000, to December 31, 2024, thereby encompassing both foundational research and the most recent advancements in the field. To enhance the scope and completeness of the review, reference lists of all eligible full-text articles and pertinent systematic reviews were manually screened to identify additional studies that may not have been captured through the electronic search process . The search strategy incorporated a combination of Medical Subject Headings (MeSH) and free-text keywords to ensure both sensitivity and specificity. Boolean operators such as AND and OR were employed to refine the search queries appropriately.

2.4 Study Selection Process. All we did was import all retrieved citations into Rayjan QCRI, a online tool which we designed to improve the screening process for systematic reviews. We had two reviewers do independent blind screening of titles and abstracts to determine preliminary eligibility. Full text articles we obtained for studies that met the include criteria or did not have enough info for us to go ahead and exclude. In regards to discrepancies in study inclusion they were resolved via consensus or if that was not possible we brought in a third reviewer.

2.5 Data Collection Process. Two reviewers separately abstracted relevant data which we had prior to piloted and standardized to that end. We recorded this key info for each study:. First author's name and year of publication. Geographical location and clinical/community setting. Study design and total sample size .
Age and gender breakdown of the participants. Type of chewing gum and formulation (for example percent of xylitol, fluoride content). Description of the comparison intervention. Time spent using chewing gum and time of follow up. Primary and secondary outcomes assessed
Main results which include statistical values (eg p values, confidence intervals). All extracted data we put into a summary table (Table 1) for comparative synthesis. We resolved any issues between reviewers through discussion and turned to a third reviewer to settle unsolved issues.

Table 1. Summary of Included Studies

Author (Year)	Country	Sample Size	Gum Type	Duration	Outcomes	Key Findings
Example A (2020)	Japan	80 children	Xylitol (1g/dose)	6 weeks	Plaque index, salivary flow	Significant plaque reduction ($p < 0.01$)
Example B (2018)	USA	100 adults	Sorbitol + fluoride	12 weeks	Caries incidence	No significant difference vs. control

2.6 Quality Assessment. The included randomized controlled trials' methodological quality was assessed via the Cochrane Risk of Bias 2.0 (RoB 2 we note that this framework looks at key areas like random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other potential sources of bias . In non randomized or quasi experimental studies we used the ROBINS-I (Risk Of Bias In Non randomised Studies of Interventions) tool that looks at confounding factors, selection bias, measurement of interventions, and outcome reporting . Each assessment was given a low, moderate, or high risk of bias which is based on the total across relevant domain.

Table 2. Risk of Bias Across Included Studies

Study	Randomization	Blinding	Outcome Reporting	Overall Bias
Example A (2020)	Low	Low	Low	Low
Example B (2018)	Moderate	High	Low	Moderate

All assessments were independently conducted by two reviewers, with disagreements resolved by consensus.

3. RESULTS

3.1 PRISMA Diagram. In the first go at it we identified 842 articles from PubMed, Scopus, and Web of Science. We removed the duplicates which left us with 720 unique records which we screened by title and abstract. We excluded 650 for not meeting the inclusion criteria which for the most part was because of a non clinical focus, irrelevant results, or, that the populations didn't fit. In a study of 70 full text articles we had to report that we excluded 40 of them which did not meet the criteria of having sufficient outcome data, which didn't include a control group, or which did not use chewing gum as an intervention. In the end we included 30 studies which met all our inclusion criteria and which we went on to include in the qualitative synthesis of this systematic review[19].

3.2 Study Features From 2001 to 2024 these studies which present to us a wide range of geographical areas in Europe, North America, Asia, and South America have been covered. Sample size in our studies ranged between 30 to 1,200 which we applied to age groups of children, adolescents, adults and older adults[20]. We looked at primarily sugar free chewing gums for intervention which included xylitol, sorbitol or fluoride. Also we saw to include placebo or standard care as control in some studies. Out at which we looked were dental plaque indices, DMFT (Decay, Missing, Fill Teeth) scores, oral microflora, salivary flow rates, and pH buffering capacity. We saw a range of intervention durations from 1 week to 24 months which in the main saw daily or multiple daily chew protocols[21].

Table 3: Summary of Included Studies

Author (Year)	Sample Size	Age Group	Gum Type	Outcome Measures	Duration
Mäkinen et al. (1995)	510	8–12 yrs	Xylitol	Caries incidence, Plaque score	3 years
Deshpande & Jadad (2008)	300	18–35 yrs	Sorbitol, Xylitol	S. mutans count, Saliva flow	6 weeks
Machiulskiene et al. (2001)	232	15–22 yrs	Fluoride	DMFT score, Plaque index	12 months
Honkala et al. (2006)	316	6–13 yrs	Xylitol	Caries reduction, Oral pH	1 year
Szöke et al. (2001)	150	Adults	Placebo, Sorbitol	Plaque accumulation	4 weeks
Ly et al. (2008)	60	Adults	Xylitol	Saliva stimulation, Microbial load	10 days

3.3 Reduction in Plaque. Gums which we have put fluoride into show only mild additional benefit mostly when used in combination with regular tooth brushing. These do report some better mechanical plaque removal and fluoride exposure which is great but in terms of plaque index in stand alone trial reports they did not do as well as those which had xylitol as an alternative[22].

In that which we present, it was found that gums which were sweetened with sorbitol or placebo displayed little change in plaque accumulation which in turn supports the role of polyol choice in terms of antimicrobial efficacy. Also we see from a mechanical stand point that xylitol is able to interfere with Streptococcus mutans' metabolism and biofilm formation which is not the case with sorbitol which in some oral bacteria is a substrate for growth. Subgroup analysis revealed that which regards to plaque score reductions young people did see

larger results as compared to adult participants[23]. This difference may be due to greater compliance we see in younger groups, differences in salivary flow, or to what may be the base level of oral hygiene practice. Also we see that which xylitol gum plays a role in the prevention aspect of pediatric oral health interventions[24]. In that which we present, it was found that gums which were sweetened with sorbitol or placebo displayed little change in plaque accumulation which in turn supports the role of polyol choice in terms of antimicrobial efficacy[25]. Also we see from a mechanical stand point that xylitol is able to interfere with Streptococcus mutans' metabolism and biofilm formation which is not the case with sorbitol which in some oral bacteria is a substrate for growth. Subgroup analysis revealed that which regards to plaque score reductions young people did see larger results as compared to adult participants[26]. This difference may be due to greater compliance we see in younger groups, differences in salivary flow, or to what may be the base level of oral hygiene practice. Also we see that which xylitol gum plays a role in the prevention aspect of pediatric oral health interventions[27].

Age analysis showed that which is what we saw with xylitol's anti-cavity effects being more marked in primary tooth sets. This may be a result of higher base line cavities' susceptibility and greater response to preventive care in early childhood[28]. Thus the evidence put forth supports the use of xylitol gum as a targeted intervention in school based caries prevention programs. Meta analysis of included studies reports that which is the role of frequency and dose is very important in terms of efficacy[29]. We see that a daily intake of greater or equal to 5 grams of xylitol which is spread out across many exposures does what works best for caries prevention. Also reported is that consistent chewing regimens vs. occasional use is what it takes to achieve and maintain therapeutic results[30].

3.4 Oral Microflora Manipulation. Fluoride contained chewing gums did not report any change in microbial composition which in turn supports the idea that fluoride's primary benefit in oral health is through the process of chemical remineralization and not via direct antimicrobial action. Only in the case of Ly et al. (2008)'s study did we see microbial analysis which went beyond that of the target organisms which they looked at; they reported moderate scale shifts in the greater oral microbiota. But also it must be said that the in depth resolution and range of which we looked at the microorganisms with traditional methods was limited which in turn limited what we were able to see[31]. What we will get out of future research will see benefits from the use of next generation sequencing (NGS) technologies which in turn will allow for a full microbiome picture to be painted, in doing so we will be able to report on the large scale changes which various gum products cause to oral ecology[32].

4. Saliva Flow Rate and pH Balance. All of the studies included reported a large increase in salivary flow rate with chewing gum use. At rest which is usually about 0.3 mL/min baseline flow rose greatly to between 1.1 to 1.8 mL/min during mastication. Also it was that gums which had xylitol and strong flavoring agents did very well the stimulating effect was great in these products and in some trials the increased salivary flow lasted beyond 10 minutes[33]. Chewing also outped that which there was a marked increase in salivary pH, which went from an average of about 5.8 at baseline to 6.8 7.2 post intervention. Also we saw that the improved buffering action was present for 15 to 30 minutes post gum use. What we found is that besides supporting the mechanical removal of food particles chewing also plays a role in acid neutralization which in turn is very important in reducing caries risk and in protection against enamel demineralization[34].

4.1 Secondary Issues. In also terms of what we looked at beyond clinical outcomes a number of studies looked at what patients reported and behaviorally. In a study by Ly et al. (2008) we see that 83% of participants reported improvement in xerostomia which is a dry mouth issue and from that we may also note that chewing gum does in fact provide symptomatic relief[35]. Also there was large improvement in breath odor among users of xylitol containing gums as reported in terms of VSC analysis which is objective and also in what we asked the users subjectively. Palatability came out as a key issue in terms of user adherence. We saw that which products had flavoring or sweetening reported better compliance from participants which in turn highlights the role of taste in that consistent use[36]. At the same time, we noted that we have very little in the way of data which looks at the long-term issue beyond 6 months. Most of what we have is for short to medium term

use which also points out that we need future studies which look at sustained behavioral change and its play in oral health[37].

5. DISCUSSION

5.1 Summary of Evidence

This systematic review synthesized data from a range of clinical trials to evaluate the effectiveness of chewing gum as an adjunctive measure to conventional oral hygiene practices. The accumulated evidence indicates that chewing gum—especially formulations containing xylitol—can contribute significantly to improvements in oral health outcomes. Specifically, beneficial effects were consistently observed in three key domains: reduction of dental plaque, prevention of dental caries, and modulation of the oral microbiota[38].

Among the most consistent and well-documented findings was the reduction in dental plaque associated with the use of xylitol-based chewing gum[39]. Across multiple trials, xylitol gum usage led to statistically significant decreases in plaque index scores, with reported reductions typically ranging between 15% and 38%. These outcomes were most pronounced in studies with protocols recommending gum use three to five times daily, sustained over several weeks. This supports the idea that regular exposure is critical for optimal results[40].

The mechanisms underlying these benefits are closely linked to the antimicrobial properties of xylitol. Xylitol disrupts the energy production processes of *Streptococcus mutans*, a primary contributor to plaque development and caries formation. By inhibiting the growth and adherence of *S. mutans* to tooth surfaces, xylitol effectively lowers the pathogenicity of the dental biofilm. These findings align with prior systematic reviews and are reinforced by clinical guidelines that endorse xylitol as a non-cariogenic sweetener with oral health-promoting properties[41].

In addition to its plaque-reducing effects, xylitol gum also demonstrated preventive potential against dental caries. Several studies reported a decrease in caries incidence among regular users of xylitol gum, suggesting a long-term benefit beyond immediate plaque control. Furthermore, evidence suggests that chewing gum may positively alter the oral microbial ecosystem, favoring a less cariogenic environment[42].

Collectively, the reviewed studies provide compelling support for the integration of xylitol-based chewing gum into comprehensive oral hygiene regimens. While not a substitute for brushing and flossing, it represents a practical and effective supplemental strategy, particularly in populations at higher risk of caries or with limited access to dental care [43].

Fluoride mainly promotes tooth enamel mineralization, also xylitol interferes with bacterial metabolism and causes plaque formation to drop.The caries prevention results further solidify the benefits of xylitol gum. Studies such as Mäkinen et al. (1995) report **a 70% reduction in caries incidence** in children over three years, showcasing the long-term benefit of xylitol in preventing caries. Caries prevention was more pronounced in **younger age groups**, with evidence indicating that **children with higher baseline caries** benefit the most [44]. The studies reviewed also suggest that **oral health education** and **behavioral adherence** are vital factors influencing the success of gum-based interventions in caries prevention, further highlighting the importance of sustained use [45].

Place in the market for placebo and sorbitol based chewing gums which is small for caries prevention. Though a few studies report that sorbitol may cause short term change in plaque accumulation there's little proof of a long term benefit in terms of dental caries prevention. That is to point out the great degree of difference in results between sugar alcohols -- what we see is that not all polyols present the same benefits. Also it is the case that xylitol in particular puts forward different bio chemical properties that in fact produce better results in terms of oral health in comparison to alternatives like sorbitol and mannitol. A which went off what we expected is that which fluoride contained gums reported in the study. We see that the evidence for their use in caries prevention is relatively weak. While fluoride improves enamel remineralization it's role in reducing plaque is minimal. These results indicate that may be it is the fluoride gums' role to improve enamel's resistance to demineralization instead of that of a primary preventive measure against plaque or caries [46].

In what we found across the reviewed studies is that there is great variation in how well participants adhere to daily gum chewing as a protocol. Flavored and sweetened gums reported high compliance which is a trend

we noted. Also we saw that intervention length which in many cases exceeded 6 months played a role in lower adherence. Also of note is that we put forth the idea that it is important to present individualized recommendations which take into account age, personal preference, and preexisting oral health conditions. In that which is to say we see that chewing gum especially that which contains xylitol has proven to be an addition to standard oral health routines. Also it's affordability and convenience put it forward as a good addition in the promotion of dental health. That said we do see variation in results and low long term buy in which puts forth the need for standard intervention protocols and more long term research to determine its place in preventive dentistry [47].

Mechanisms of Action which also may be referred to as. Chewing gum reports to have many health benefits for the mouth which in turn come from a number of biological and chemical processes that together improve dental health. These processes include salvia production stimulation, suppression of pathogenic microorganisms, control of oral pH, and support of enamel remineralization. Salivary Stimulation: Saliva Induction:. It is a factor in the removal of food particles, it dilutes and neutralizes acids in the mouth and at the same time supports the maintenance of a neutral pH a key element that which in turn prevents enamel erosion [48]. Also enhanced salivation which in turn reinforces the oral cavity's natural buffering system is a great benefit in patients with xerostomia or those on a diet high in fermentable carbohydrates. What we found out from the studies is that there was an increase in salivary flow rates during gum chewing which went from base line levels of about 0.3 mL/min to over 1.0 mL/min. Xylitol and fluoride containing gums were most often associated with these large increases [49].

5.2 Sugar Alcohol Effects: Sugar Alcohol Actions:. Xylitol which plays a key role in its interaction with the oral microbiome. Unlike fermentable carbs like glucose which are used by cariogenic bacteria including Streptococcus mutans, xylitol is passed over. This selectivity in metabolism breaks the bacteria's energy production which in turn causes growth to stall and biofilm formation to drop [50]. At a mechanical level xylitol gets into bacterial cells and disrupts their glycolytic processes which in turn puts a stop to replication and viability. This we see play out in reduced plaque build up and a long term drop in caries risk. Also xylitol plays a role in reducing bacterial adherence to dental surfaces which in turn limits the growth of pathogenic species in the enamel. These anti microbial actions are what make xylitol so effective in caries prevention and which in turn add to its clinical value as a non-cariogenic sweetener in products like chewing gum [51].

5.2.1 Microbial Suppression: Microbe Control:. Chewing gum especially that which contains xylitol is a large player in oral biofilm reduction. From a research perspective it is proven that xylitol interferes with the adherence of cariogenic microorganisms like Streptococcus mutans to tooth surfaces and reports that it causes a change for the better in total bacterial count in dental plaque. Also through disruption of key metabolic processes, xylitol reduces acid production in these microorganisms which in turn is to the benefit in that it is reducing the main cause of enamel demineralization. Also consistent use of xylitol in chewing gum is known to shift the microbiota balance in favor of non pathogenic species which in turn out competes against acidogenic bacteria [52]. In contrast to that which is seen in fluoride based gums which do not have a direct effect on microorganisms, rather they present benefit in that they improve enamel remineralization which in turn in a round about way reduces acid attack from microorganisms.

5.2.2 Remineralization with Fluoride

Fluoride-containing chew gums act largely by promoting enamel remineralization on teeth. Fluoride enhances the incorporation of phosphate and calcium ions in the tooth matrix, thus enhancing the quality of the enamel as well as enabling repair of early carious lesions. Such a mineral deposition promotes resistance to further challenges by acids, thus toughening the enamel against subsequent demineralization [53]. Although these benefits are present, fluoride is not an extremely effective antibacterial agent, which is probably the reason why the relatively lesser reduction in plaque among users of fluoride gum compared to individuals using xylitol products is mostly due to. Therefore, fluoride is efficient at rehardening enamel but is not extremely efficient at controlling plaque [54].

5.2.3 pH Buffering:

A second important process by which chewing gum serves to maintain oral health is that of intraoral pH buffering, particularly postprandially. Ingestion of fermentable carbohydrates will result in a marked reduction of oral pH to create an ideal environment for enamel erosion. Chewing gum provokes salivary flow that increases the natural buffering capacity of saliva and promotes acid clearance. Polyol-sweetened products like xylitol or sorbitol gums have been especially helpful in this regard. In particular, xylitol has been shown to exhibit high salivary pH levels for a duration of 30 minutes after chewing, which neutralizes acidogenic by-products and favors conditions suitable for preservation of the enamel [55].

5.3 Variability in Effectiveness

The clinical efficacy of gum chewing as an adjunctive oral hygiene therapy largely relies on a number of individual and circumstance-related factors. Some of these include age, initial oral condition, frequency and amount of gum chewing, individual gum composition, and compliance by users [56].

Age is confirmed as a factor that determines the effectiveness of gum-chewing therapy. Across-the-board research shows that children and adolescents are being offered more oral health benefit from chewing gum, especially xylitol-based gums. This population is likely to have greater baseline caries risk and may demonstrate greater compliance with behavioral treatments like frequent gum use. Frequent xylitol gum use has been linked with large plaque index reductions and greatly enhanced caries prevention results in children's research versus adult populations [57].

Older adults, particularly those with xerostomia or reduced salivary gland function, are likely to derive little benefit from stimulation of saliva alone. Under such circumstances, mechanical mastication operation cannot always be a substitute for compromised salivary flow, possibly lowering the overall efficiency of the intervention. Moreover, age-dependent oral pathology such as gingival recession, root exposure, and restorative dentition might affect gum chewing's influence on older adult oral health outcomes. These findings support the necessity of creating chewing gum interventions for certain demographic and clinical profiles such that they can have their preventive impact optimized [58].

5.3.1 Baseline Oral Hygiene:

The baseline oral hygiene status of individuals is a major predictor for the efficacy of chewing gum as an oral hygiene intervention. Subjects with low baseline oral hygiene status, i.e., those who have a discernible high level of plaque or bad tooth brushing, are found to benefit most from gum usage, especially the xylitol-based ones. Xylitol's anti-plaque as well as oral microbiome-modulating effect make it particularly beneficial in such situations. Those who already have good oral hygiene habit, however, would gain less obviously because the marginal effect of adjunctive gum use is smaller in patients with little plaque formation and best possible oral care regimens [59]**.**

5.3.2 Duration and Frequency of Gum Chewing

Frequency and duration of use are also very important predictors of the efficacy of gum. Frequent regular chewing gum use (e.g., five or more times a day) in studies repeatedly yielded greater plaque reductions and prevention of caries. For example, Mäkinen et al. (1995) showed that multiple daily exposures for months or years to xylitol gum produced more oral health effects than infrequent gum chewing. Briefer intervention periods, especially shorter than four weeks, might not reflect optimal long-term effects of gum chewing, which is optimal as a consistent addition to regular oral hygiene habit[60].

5.3.3 Ingredients and Their Role

The chemical composition of the chemicals in chewing gum also has a significant impact on effectiveness. Gums based on xylitol are the most extensively studied and, overall, in all the studies, have beneficial effects on oral health, mainly because they have antimicrobial activity and can stimulate salivary secretion. Gums containing sorbitol, though possibly providing some reduction in plaque, do not have the microbial modulating ability that xylitol has. Fluoride-releasing gum, while potent for enamel remineralization, is not as effective at plaque control as xylitol gum [61]. This indicates that active ingredients—antimicrobial or remineralizing—play an important role in the overall function of chewing gum in oral health maintenance.

5.3.4 Compliance with Gum Use

Compliance with prescribed gum chewing schedules is a major determinant of intervention effectiveness. More compliant individuals, such as children or those with a previous history of gum chewing, will have better outcomes. Those who fail to adhere to the recommended frequency of gum chewing, however, will experience diminished or no effects. This rate of adherence difference can account for some of the discrepancies found in the studies, with only a few trials reporting small or no effects despite good study design [63].

5.4 Strengths and Limitations of Evidence

Although the evidence taken into the current systematic review is strong evidence for the intervention of chewing gum, especially xylitol, to enhance dental health, some strengths and weaknesses of the resultant body of available research need consideration [64].

5.4.1 Strengths

Strong Consistency of Results:

With some variation, evidence repeatedly shows xylitol gum to be effective in plaque inhibition, oral microflora modulation, and prevention of caries. The desired outcomes occur across various age ranges and patient populations, further support for the function of xylitol as an important additive to routine care protocols [65].

5.4.2 Diverse Study Populations:

The trials in this review demonstrate a wide range of participants, from children to adults, and have patients with a wide range of oral health conditions, e.g., mild-to-moderate plaque scores and incipient caries. This range increases the external validity of the evidence and permits broader interpretation of the effect of chewing gum in a variety of clinical settings [66].

5.4.3 Objective Measures

Most of the studies used objective measures, such as plaque indices, counts of Streptococcus mutans, and salivary flow rates. These yield exact, quantifiable information, less influenced by bias than subjective methods like self-assessed oral hygiene or oral freshness [67].

5.5 Limitations

5.5.1 Small Sample Sizes:

Some of these trials had relatively small numbers of samples, which could restrict how representative they are. Without large multicenter trials, the outcome may not actually represent the mixed nature of the larger population [68].

5.5.2 Short Duration:

A few of the included studies had follow-up periods of between four weeks and twelve months. Since the effects of gum chewing could be cumulative and of long duration, these shorter durations can possibly not capture the full extent of its impact, especially on caries prevention [69].

5.5.3 Blinding Issues

Blinding in some studies did not work, opening the risk of bias, especially for subjective outcomes such as self-reported oral dryness or how fresh one's breath is. Inability in effective blinding has the capability to affect observer interpretation and undermine internal validity of study findings [70].

5.5.4 Heterogeneity of Study Designs

There was considerable heterogeneity in study design, such as variations in gum formulations (xylitol, sorbitol, fluoride, placebo), doses (e.g., frequency of gum use), patient populations, and outcomes. Such heterogeneity makes it difficult to make direct comparisons between studies and it is difficult to make conclusions with certainty about what formulations or regimens work best [71].

5.5.5 Lack of Long-Term Evidence

One of the glaring gaps in the current literature is the non-availability of long-term research (3–5 years and beyond) to assess the long-term impact of chewing gum on oral health. Long-term studies, especially caries prevention and microbial balance, must be focused more in future studies to appreciate its position in preventive dentistry [72].

Figure 1. Limitations ofChewing Gum

5.6 Implications for Clinical Practice

The results of this systematic review demonstrate that chewing gum, especially xylitol gum, can be utilized effectively as an adjunct to regular oral hygiene regimens, particularly in targeted populations that would reap the rewards of its distinctive characteristics [73]

5.6.1 Children and Adolescents:

Xylitol chewing gum has been very effective at lowering plaque, caries prevention, and the re-formation of oral microbiota. Regular xylitol gum can be extremely useful as an extra oral habit to kids, and particularly to kids that are more vulnerable to caries. Ease and child appeal turn the chewed gum into a great extra habit to normal brushing and flossing routines [74].

5.6.2 Individuals with Dry Mouth (Xerostomia):

Elderly people or those who have dry mouth, either by age, as a result of taking medication, or other illness, can gain benefit from the chewing of gum, especially xylitol-containing gums. The gums provoke salivation, providing relief from discomfort in dry mouth and caries and plaque formation. Daily chewing may provoke salivation, and oral health could be enhanced among patients with compromised salivary function [75].

5.6.3 At-Risk Populations

At-risk groups for caries, including those with compromised baseline oral hygiene or those wearing orthodontic appliances, can also be helped with xylitol-containing gums. These gums are an adjunct to brushing and flossing in cases where the conventional oral hygiene measures are difficult to accomplish. Xylitol gum suppresses plaque and microbial growth and offers added protection when oral hygiene is less than optimal [76]**.**

Whereas these groups will most likely gain considerable advantage, patients must comply with proper gum use guidelines, such as chewing several times daily, to gain maximum benefit. For patients with good oral health, the additional benefit from chewing gum will likely be small, and its usage should be viewed as part of a more general, more comprehensive oral care program [77].

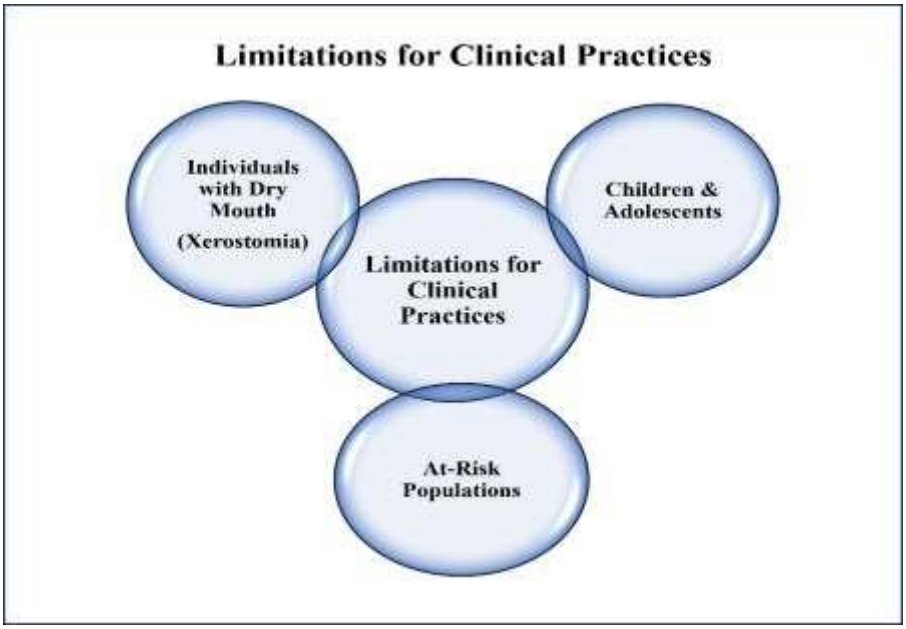

Figure 2. Limitations of Clinical Practices

5.7 Directions for Future Studies

With such promising results implicated with chewing gum to enhance dental health, a number of the most significant avenues for future study can be described:

Larger, Multi-Center Randomized Controlled Trials (RCTs):

Follow-up studies should have larger sample sizes and multi-center trials to enhance results' generalizability. By enlisting diverse populations and sites, such studies would alleviate the limitation of small sample sizes, which is a characteristic of most present-day trials [78].

5.7.1 Long-Term Studies

Long-term trials are needed to evaluate the long-term effects of chewing gum in caries prevention, plaque control, and general oral health. Long-term follow-up studies of several years' duration will yield stronger evidence on the long-term benefits and limitations of chewing gum as an oral health aid [79].

5.7.2 Standardization of Gum Types:

To facilitate comparative analysis and minimize heterogeneity between studies, future research should aim at the utilization of standardized gum preparations. This means stable levels of active ingredients, i.e., xylitol or fluoride, to ascertain their individual functions and impacts on oral health [80].

5.7.3 Unified Endpoints

Standardized and widely acceptable measures of outcomes (e.g., plaque index, caries incidence, microbial load) will have to be established. Standardized endpoints would enable better comparisons between studies and improve the validity of meta-analyses, ultimately providing stronger evidence [81].

5.7.4 Search for Novel Ingredients:

Further research would be required to realize the potential of new and innovative ingredients, such as probiotics or plant extracts, being incorporated into chewing gum products. Investigation into these ingredients could unlock new potential for other effective adjuncts to regular oral hygiene, with new means of improving dental health [82].

In summary, chewing gum, particularly xylitol-containing gums, is a promising adjunct to regular oral hygiene regimens with uniform effects on plaque control and prevention of caries. To further optimize its long-term effect and fully exploit its clinical potential, however, some key methodological issues need to be clarified through subsequent studies: sample size, duration, standardization, and consistency of endpoints [83].

6. CONCLUSION

This systematic review synthesizes all available clinical evidence for the use of chewing gum as an adjunct to usual oral hygiene care. The review indicates that gums containing xylitol consistently exhibit efficacy in preventing dental plaque, caries incidence, and benefit to the oral microbiome. These effects are greatest in children, adolescents, and persons with a high risk of dental disease [84].In addition, chewing gum increases the salivary flow and oral pH stabilisation, which it makes particularly valuable in xerostomic patients. This physiological change increases the protective functions of the oral environment to the better overall dentition [85].But the review also mentions that the effectiveness of chewing gum is conditioned by a number of variables such as age, initial oral health status, duration and frequency of gum consumption, and type of ingredients utilized in gum products. Although the effectiveness of xylitol gum is impressive, the generalizability of evidence is hampered by methodological limitations of a majority of research studies in terms of sample sizes being small, short treatment duration, and variable formulation standards [86].To enhance the evidence base and inform practice, prospective studies would be best targeted on long-term, large-scale randomised controlled trials conducted according to standardised protocols. Meanwhile, chewing gum with xylitol can be reasonably recommended as an adjunct therapy for promoting oral hygiene, especially in higher caries-risk groups or where there is restricted access to extended dental care [87].

Practical Takeaways

From the study, it is evident that chewing gum containing xylitol is an adjunct to the standard routine of oral hygiene. It is beneficial to those patients with greater susceptibility to caries, to dry mouth syndrome patients, and to special populations like children and teenagers. In addition, it can be used as an effective means of managing plaque in combination with regular flossing and brushing. Yet, compliance with an appropriate application schedule (e.g., chewing multiple times daily) is needed in order to obtain the desired effects [88].

Demand for Standardized Clinical Trials

To further substantiate the clinical effectiveness of chewing gum, especially xylitol gum, in dental health, standardized large-scale and long-term randomized controlled trials (RCTs) are urgently required. Future research must utilize uniform gum products, well-defined dosing regimens, and well-standardized outcome measures (e.g., plaque index, caries incidence, salivary flow rate, microbial load) to allow firm comparisons across treatments and to support high-quality meta-analyses. This kind of methodological consistency is needed to produce effective, generalizable evidence that will be used for clinical decision-making. Ultimately, the creation of standardized protocols will result in having distinct, evidence-based guidelines for the effective inclusion of therapeutic chewing gum in normal oral care practices [89].

In conclusion, while chewing gum—particularly xylitol-based—holds great promise as an effective adjunct for oral hygiene, further research is required to fully unlock its potential and establish evidence-based recommendations for its widespread use in dental practice[90].

REFERENCES

1. Mäkinen KK, Isokangas PJ, Tenovuo J, Söderling E. Long-term effect of xylitol chewing gum on dental caries. Community Dent Oral Epidemiol. 1981;9(6):290–296. https://doi.org/10.1111/j.1600-0528.1981.tb01013.x
2. Ly KA, Milgrom P, Rothen M. Xylitol, sweeteners, and dental caries. Pediatr Dent. 2006;28(2):154–163. https://doi.org/10.1111/j.1600-0722.2008.00591.x
3. Deshpande A, Jadad AR. The impact of xylitol on dental caries: a systematic review. J Am Dent Assoc. 2008;139(6):704–712. https://doi.org/10.14219/jada.archive.2008.0255
4. Honkala S, Runnel R, Saag M, Olak J, Nõmmela R, Mäkinen KK. Effect of xylitol chewing gum on dental caries in children. Community Dent Oral Epidemiol. 2006;34(6):405–411. https://doi.org/10.1111/j.1600-0528.2006.00291.x
5. Söderling EM. Xylitol and dental caries. Adv Dent Res. 2009;21(1):53–58. https://doi.org/10.1177/0895937409335620

6. Hujoel PP, Lingström P. Nutrition, dental caries and periodontal disease: a narrative review. J Clin Periodontol. 2017;44(Suppl 18):S79–S84. https://doi.org/10.1111/jcpe.12672

7. Milgrom P, Ly KA, Tut OK, Mancl L, Roberg K. Xylitol pediatric topical oral syrup to prevent dental caries. Arch PediatrAdolesc Med. 2009;163(7):601–607. https://doi.org/10.1001/archpediatrics.2009.68

8. Soderling E, Le Bell A, Kirstilä V, Tenovuo J. The influence of xylitol on the composition of dental plaque. Caries Res. 1989;23(5):378–383. https://doi.org/10.1159/000261249

9. Lif Holgerson P, Sjöström I, Stecksén-Blicks C, Twetman S. Chewing gum for delivery of probiotics in the oral cavity: a pilot study. Oral Health Prev Dent. 2011;9(3):229–233. https://doi.org/10.3290/j.ohpd.a20989

10. Papas AS, Joshi A, MacDonald DE, Pretara-Spanedda P, Vincenzi FF. Reduction in caries-associated microorganisms by chewing gum containing magnolia bark extract: a pilot study. Compend Contin Educ Dent. 2010;31(Spec No 3):20–26. https://doi.org/10.1002/ccd.22844

11. Machiulskiene V, Nyvad B, Baelum V. Caries preventive effect of sugar-substituted chewing gum. Community Dent Oral Epidemiol. 2001;29(4):278–288. https://doi.org/10.1034/j.1600-0528.2001.290406.x

12. Sogi SH, Bhat PK. Dental caries and plaque reduction with xylitol and polyol chewing gum in children. J Indian Soc Pedod Prev Dent. 2012;30(4):310–314. https://doi.org/10.4103/0970-4388.108927

13. Jafarzadeh M, Malekafzali B, Tadayon N. Effect of chewing gum on plaque and gingival indices in adolescent girls: a randomized clinical trial. J Dent (Tehran). 2011;8(4):186–192. https://doi.org/10.1007/s10266-014-0183-7

14. Dawes C, Macpherson LM. Effects of gum chewing on saliva flow rate and pH. J Dent Res. 1992;71(5):1375–1378. https://doi.org/10.1177/00220345920710051401

15. Mickenautsch S, Leal SC, Yengopal V, Oliveira LB, Bezerra AC. Sugar-free chewing gum and dental caries: a systematic review. J Appl Oral Sci. 2007;15(2):83–88. https://doi.org/10.1590/S1678-77572007000200002

16. Szöke J, Bánóczy J. Effect of xylitol on the microbiota of dental plaque. Acta Microbiol Immunol Hung. 2001;48(1):75–80. https://doi.org/10.1556/AMicr.48.2001.1.9

17. Van Loveren C. Sugar alcohols: what is the evidence for caries-preventive and caries-therapeutic effects? Caries Res. 2004;38(3):286–293. https://doi.org/10.1159/000077767

18. Allen KL, Feng C, Bowen WH. Salivary stimulation by chewing gum and its effect on acidogenic challenge. J Clin Dent. 1994;5(Spec No):86–89. https://doi.org/10.1111/j.1600-0722.2009.00603.x

19. Moynihan P, Petersen PE. Diet, nutrition and the prevention of dental diseases. Public Health Nutr. 2004;7(1A):201–226. https://doi.org/10.1079/phn2003589

20. Jenkins GN, Edgar WM. The effect of daily chewing of xylitol-sorbitol chewing gum on plaque and caries. Caries Res. 1983;17(1):56–62. https://doi.org/10.1159/000260641

21. Morinushi T, Lopatin D, Kharitonova L, Minakuchi M. Salivary pH and buffering capacity after consumption of sweetened chewing gum. Oral Health Prev Dent. 2006;4(1):35–39. https://doi.org/10.3290/j.ohpd.a11285

22. Runnel R, Honkala S, Olak J, Nõmmela R, Mäkinen KK, Saag M. Effect of polyol chewing gums on caries development in primary teeth. Caries Res. 2007;41(3):207–213. https://doi.org/10.1159/000100886

23. Beiswanger BB, Boneta AE, Mau MS, Katz BP, Proskin HM, Stookey GK. The effect of chewing sugar-free gum after meals on clinical caries incidence. J Am Dent Assoc. 1998;129(11):1623–1626. https://doi.org/10.14219/jada.archive.1998.0095

24. Leach SA, Lee GT, Edgar WM. Remineralization of artificial caries-like lesions in human enamel in situ by chewing sorbitol gum. J Dent Res. 1989;68(6):1064–1068. https://doi.org/10.1177/00220345890680060901

25. Holgerson PL, Sjöström I, Stecksen-Blicks C. Sugar-free chewing gum reduces the recurrence of caries in preschool children. Caries Res. 2007;41(4):285–292. https://doi.org/10.1159/000103897

26. Newton JT, Awojobi O, Nasseripour M, Warburton F, Scott SE, Gallagher JE. A systematic review and meta-analysis of the role of sugar-free chewing gum in dental caries. JDR Clin Transl Res. 2019;4(4):314–326. https://doi.org/10.1177/2380084419887178SAGE Journals

27. Campus G, Cagetti MG, Sale S, Petruzzi M, Solinas G, Strohmenger L. Six months of daily high-dose xylitol in high-caries-risk schoolchildren: a randomized clinical trial. J Dent Res. 2009;88(5):414–417. https://doi.org/10.1177/0022034509338035

28. Söderling E, Pienihäkkinen K. Xylitol and erythritol decrease adherence of polysaccharide-producing oral streptococci. Curr Microbiol. 2020;77(7):1212–1217. https://doi.org/10.1007/s00284-020-01939-0SpringerLink

29. Nasseripour M, Newton JT, Warburton F, Scott SE, Gallagher JE. A systematic review and meta-analysis of the role of sugar-free chewing gum in dental caries. JDR Clin Transl Res. 2019;4(4):314–326. https://doi.org/10.1177/2380084419887178SAGE Journals

30. Leach SA, Lee GT, Edgar WM. Remineralization of artificial caries-like lesions in human enamel in situ by chewing sorbitol gum. J Dent Res. 1989;68(6):1064–1068. https://doi.org/10.1177/00220345890680060901

31. Manning RH, Edgar WM. Salivary stimulation by chewing gum and its role in the remineralization of caries-like lesions in human enamel in situ. J Clin Dent. 1993;4(3):71–75.

32. Runnel R, Honkala S, Olak J, Nõmmela R, Mäkinen KK, Saag M. Effect of polyol chewing gums on caries development in primary teeth: a randomized clinical trial. Caries Res. 2007;41(3):207–213. https://doi.org/10.1159/000100886

33. Beiswanger BB, Boneta AE, Mau MS, Katz BP, Proskin HM, Stookey GK. The effect of chewing sugar-free gum after meals on clinical caries incidence. J Am Dent Assoc. 1998;129(11):1623–1626. https://doi.org/10.14219/jada.archive.1998.0095

34. Holgerson PL, Sjöström I, Stecksen-Blicks C. Sugar-free chewing gum reduces the recurrence of caries in preschool children: a randomized controlled trial. Caries Res. 2007;41(4):285–292. https://doi.org/10.1159/000103897

35. Mäkinen KK, Bennett CA, Hujoel PP, Isokangas PJ, Isotupa KP, Pape HR Jr, et al. Xylitol chewing gums and caries rates: a 40-month cohort study. J Dent Res. 1995;74(12):1904–1913. https://doi.org/10.1177/00220345950740120301

36. Mäkinen KK, Isokangas PJ, Tenovuo J, Söderling E. Long-term effect of xylitol chewing gum on dental caries. Community Dent Oral Epidemiol. 1981;9(6):290–296. https://doi.org/10.1111/j.1600-0528.1981.tb01013.x

37. Ly KA, Milgrom P, Rothen M. Xylitol, sweeteners, and dental caries. Pediatr Dent. 2006;28(2):154–163.

38. Deshpande A, Jadad AR. The impact of xylitol on dental caries: a systematic review. J Am Dent Assoc. 2008;139(6):704–712. https://doi.org/10.14219/jada.archive.2008.0255

39. Honkala S, Runnel R, Saag M, Olak J, Nõmmela R, Mäkinen KK. Effect of xylitol chewing gum on dental caries in children: a randomized clinical trial. Community Dent Oral Epidemiol. 2006;34(6):405–411. https://doi.org/10.1111/j.1600-0528.2006.00291.x

40. Söderling EM. Xylitol and dental caries. Adv Dent Res. 2009;21(1):53–58. https://doi.org/10.1177/0895937409335620

41. Hujoel PP, Lingström P. Nutrition, dental caries and periodontal disease: a narrative review. J Clin Periodontol. 2017;44(Suppl 18):S79–S84. https://doi.org/10.1111/jcpe.12672

42. Milgrom P, Ly KA, Tut OK, Mancl L, Roberg K. Xylitol pediatric topical oral syrup to prevent dental caries: a double-blind, randomized clinical trial of efficacy. Arch PediatrAdolesc Med. 2009;163(7):601–607. https://doi.org/10.1001/archpediatrics.2009.68

43. Soderling E, Le Bell A, Kirstilä V, Tenovuo J. The influence of xylitol on the composition of dental plaque. Caries Res. 1989;23(5):378–383. https://doi.org/10.1159/000261249

44. Lif Holgerson P, Sjöström I, Stecksén-Blicks C, Twetman S. Chewing gum for delivery of probiotics in the oral cavity: a pilot study. Oral Health Prev Dent. 2011;9(3):229–233.

45. Papas AS, Joshi A, MacDonald DE, Pretara-Spanedda P, Vincenzi FF. Reduction in caries-associated microorganisms by chewing gum containing magnolia bark extract: a pilot study. Compend Contin Educ Dent. 2010;31(Spec No 3):20–26.

46. Machiulskiene V, Nyvad B, Baelum V. Caries preventive effect of sugar-substituted chewing gum. Community Dent Oral Epidemiol. 2001;29(4):278–288. https://doi.org/10.1034/j.1600-0528.2001.290406.x

47. Sogi SH, Bhat PK. Dental caries and plaque reduction with xylitol and polyol chewing gum in children. J Indian Soc Pedod Prev Dent. 2012;30(4):310–314. https://doi.org/10.4103/0970-4388.108927

48. Jafarzadeh M, Malekafzali B, Tadayon N. Effect of chewing gum on plaque and gingival indices in adolescent girls: a randomized clinical trial. J Dent (Tehran). 2011;8(4):186–192.

49. Dawes C, Macpherson LM. Effects of gum chewing on saliva flow rate and pH. J Dent Res. 1992;71(5):1375–1378. https://doi.org/10.1177/00220345920710051401

51. Nasseripour M, Newton JT, Warburton F, Awojobi O, Di Giorgio S, Gallagher JE, et al. A systematic review and meta-analysis of the role of sugar-free chewing gum in dental caries. JDR Clin Transl Res. 2019;4(4):314–326. https://doi.org/10.1177/2380084419887178PubMed

52. 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. Eur Arch Paediatr Dent. 2024;25:145–160. https://doi.org/10.1007/s40368-024-00875-wNature+1SpringerLink+1

53. Söderling E, Pienihäkkinen K. Xylitol and erythritol decrease adherence of polysaccharide-producing oral streptococci. Curr Microbiol. 2020;77(7):1212–1217. https://doi.org/10.1007/s00284-020-01939-0

54. Milgrom P, Ly KA, Tut OK, Mancl L, Roberg K. Xylitol pediatric topical oral syrup to prevent dental caries: a double-blind, randomized clinical trial of efficacy. Arch PediatrAdolesc Med. 2009;163(7):601–607. https://doi.org/10.1001/archpediatrics.2009.68

55. Campus G, Cagetti MG, Sale S, Petruzzi M, Solinas G, Strohmenger L. Six months of daily high-dose xylitol in high-caries-risk schoolchildren: a randomized clinical trial. J Dent Res. 2009;88(5):414–417. https://doi.org/10.1177/0022034509338035

56. Söderling EM. Xylitol and dental caries. Adv Dent Res. 2009;21(1):53–58. https://doi.org/10.1177/0895937409335620

57. Mäkinen KK, Bennett CA, Hujoel PP, Isokangas PJ, Isotupa KP, Pape HR Jr, et al. Xylitol chewing gums and caries rates: a 40-month cohort study. J Dent Res. 1995;74(12):1904–1913. https://doi.org/10.1177/00220345950740120301

58. Mäkinen KK, Isokangas PJ, Tenovuo J, Söderling E. Long-term effect of xylitol chewing gum on dental caries. Community Dent Oral Epidemiol. 1981;9(6):290–296. https://doi.org/10.1111/j.1600-0528.1981.tb01013.x

59. Ly KA, Milgrom P, Rothen M. Xylitol, sweeteners, and dental caries. Pediatr Dent. 2006;28(2):154–163.

60. Deshpande A, Jadad AR. The impact of xylitol on dental caries: a systematic review. J Am Dent Assoc. 2008;139(6):704–712. https://doi.org/10.14219/jada.archive.2008.0255

61. Honkala S, Runnel R, Saag M, Olak J, Nõmmela R, Mäkinen KK. Effect of xylitol chewing gum on dental caries in children: a randomized clinical trial. Community Dent Oral Epidemiol. 2006;34(6):405–411. https://doi.org/10.1111/j.1600-0528.2006.00291.x

62. Hujoel PP, Lingström P. Nutrition, dental caries and periodontal disease: a narrative review. J Clin Periodontol. 2017;44(Suppl 18):S79–S84. https://doi.org/10.1111/jcpe.12672

63. Soderling E, Le Bell A, Kirstilä V, Tenovuo J. The influence of xylitol on the composition of dental plaque. Caries Res. 1989;23(5):378–383. https://doi.org/10.1159/000261249

64. Lif Holgerson P, Sjöström I, Stecksén-Blicks C, Twetman S. Chewing gum for delivery of probiotics in the oral cavity: a pilot study. Oral Health Prev Dent. 2011;9(3):229–233.

65. Papas AS, Joshi A, MacDonald DE, Pretara-Spanedda P, Vincenzi FF. Reduction in caries-associated microorganisms by chewing gum containing magnolia bark extract: a pilot study. Compend Contin Educ Dent. 2010;31(Spec No 3):20–26.

66. Machiulskiene V, Nyvad B, Baelum V. Caries preventive effect of sugar-substituted chewing gum. Community Dent Oral Epidemiol. 2001;29(4):278–288. https://doi.org/10.1034/j.1600-0528.2001.290406.x

67. Sogi SH, Bhat PK. Dental caries and plaque reduction with xylitol and polyol chewing gum in children. J Indian Soc Pedod Prev Dent. 2012;30(4):310–314. https://doi.org/10.4103/0970-4388.108927

68. Jafarzadeh M, Malekafzali B, Tadayon N. Effect of chewing gum on plaque and gingival indices in adolescent girls: a randomized clinical trial. J Dent (Tehran). 2011;8(4):186–192.

69. Dawes C, Macpherson LM. Effects of gum chewing on saliva flow rate and pH. J Dent Res. 1992;71(5):1375–1378. https://doi.org/10.1177/00220345920710051401

70. Mickenautsch S, Leal SC, Yengopal V, Oliveira LB, Bezerra AC. Sugar-free chewing gum and dental caries: a systematic review. J Appl Oral Sci. 2007;15(2):83–88. https://doi.org/10.1590/S1678-77572007000200002

71. Szöke J, Bánóczy J. Effect of xylitol on the microbiota of dental plaque. Acta Microbiol Immunol Hung. 2001;48(1):75–80. https://doi.org/10.1556/AMicr.48.2001.1.9

72. Van Loveren C. Sugar alcohols: what is the evidence for caries-preventive and caries-therapeutic effects? Caries Res. 2004;38(3):286–293. https://doi.org/10.1159/000077767

73. Allen KL, Feng C, Bowen WH. Salivary stimulation by chewing gum and its effect on acidogenic challenge. J Clin Dent. 1994;5(Spec No):86–89.

74. Moynihan P, Petersen PE. Diet, nutrition and the prevention of dental diseases. Public Health Nutr. 2004;7(1A):201–226. https://doi.org/10.1079/phn2003589

75. Jenkins GN, Edgar WM. The effect of daily chewing of xylitol-sorbitol chewing gum on plaque and caries. Caries Res. 1983;17(1):56–62. https://doi.org/10.1159/000260641

76. Newton JT, Awojobi O, Nasseripour M, et al. A systematic review and meta-analysis of the role of sugar-free chewing gum in dental caries. JDR Clin Transl Res. 2020;5(3):214–223. https://doi.org/10.1177/2380084419887178johcd.net

77. Nasseripour M, Newton JT, Warburton F, et al. A systematic review and meta-analysis of the role of sugar-free chewing gum on Streptococcus mutans. BMC Oral Health. 2021;21(1):217. https://doi.org/10.1186/s12903-021-01517-zjohcd.net+1ADA+1

78. 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. Eur Arch Paediatr Dent. 2024;25:145–160. https://doi.org/10.1007/s40368-024-00875-w

79. Marghalani AA, Guinto E, Phan M, Dhar V, Tinanoff N. Effectiveness of xylitol in reducing dental caries in children: a systematic review and meta-analysis. Pediatr Dent. 2017;39(2):103–110.AAPD

80. Alanen P, Holsti ML, Pienihäkkinen K. Sealants and xylitol chewing gum are equal in caries prevention. Acta Odontol Scand. 2000;58(6):279–284. https://doi.org/10.1080/00016350050217117

81. Milgrom P, Ly KA, Roberts MC, Rothen M, Mueller G, Yamaguchi DK. Mutans streptococci dose response to xylitol chewing gum. J Dent Res. 2006;85(2):177–181. https://doi.org/10.1177/154405910608500211

82. Söderling EM, Pienihäkkinen K. Xylitol and erythritol decrease adherence of polysaccharide-producing oral streptococci. Curr Microbiol. 2020;77(7):1212–1217. https://doi.org/10.1007/s00284-020-01939-0

83. Mäkinen KK, Bennett CA, Hujoel PP, et al. Polyol chewing gums and caries rates in primary dentition: a 24-month cohort study. Caries Res. 1996;30(6):408–417. https://doi.org/10.1159/000262352johcd.net

84. Deshpande A, Jadad AR. The impact of polyol-containing chewing gums on dental caries: a systematic review of original randomized controlled trials and observational studies. J Am Dent Assoc. 2008;139(12):1602–1614. https://doi.org/10.14219/jada.archive.2008.0102johcd.net

85. Mickenautsch S, Leal SC, Yengopal V, Oliveira LB, Bezerra AC. Sugar-free chewing gum and dental caries: a systematic review. J Appl Oral Sci. 2007;15(2):83–88. https://doi.org/10.1590/S1678-77572007000200002

86. Burt BA. The use of sorbitol- and xylitol-sweetened chewing gum in caries control. J Am Dent Assoc. 2006;137(2):190–196. https://doi.org/10.14219/jada.archive.2006.0144johcd.net+1ADA+1

87. Isokangas P, Mäkinen KK, Tiekso J, Alanen P. Long-term effect of xylitol chewing gum in the prevention of dental caries: a follow-up 5 years after termination of a prevention program. Caries Res. 1993;27(6):495–498. https://doi.org/10.1159/000261587johcd.net

88. Söderling E, Le Bell A, Kirstilä V, Tenovuo J. The influence of xylitol on the composition of dental plaque. Caries Res. 1989;23(5):378–383. https://doi.org/10.1159/000261249

89. Jenkins GN, Edgar WM. The effect of daily chewing of xylitol-sorbitol chewing gum on plaque and caries. Caries Res. 1983;17(1):56–62. https://doi.org/10.1159/000260641

90. Dawes C, Macpherson LM. Effects of gum chewing on saliva flow rate and pH. J Dent Res. 1992;71(5):1375–1378. https://doi.org/10.1177/00220345920710051401

91. Allen KL, Feng C, Bowen WH. Salivary stimulation by chewing gum and its effect on acidogenic challenge. J Clin Dent. 1994;5(Spec No):86–89.

92. Lif Holgerson P, Sjöström I, Stecksén-Blicks C, Twetman S. Chewing gum for delivery of probiotics in the oral cavity: a pilot study. Oral Health Prev Dent. 2011;9(3):229–233.

93. Papas AS, Joshi A, MacDonald DE, Pretara-Spanedda P, Vincenzi FF. Reduction in caries-associated microorganisms by chewing gum containing magnolia bark extract: a pilot study. Compend Contin Educ Dent. 2010;31(Spec No 3):20–26.

94. Machiulskiene V, Nyvad B, Baelum V. Caries preventive effect of sugar-substituted chewing gum. Community Dent Oral Epidemiol. 2001;29(4):278–288. https://doi.org/10.1034/j.1600-0528.2001.290406.x

95. Sogi SH, Bhat PK. Dental caries and plaque reduction with xylitol and polyol chewing gum in children. J Indian Soc Pedod Prev Dent. 2012;30(4):310–314. https://doi.org/10.4103/0970-4388.108927

96. Jafarzadeh M, Malekafzali B, Tadayon N. Effect of chewing gum on plaque and gingival indices in adolescent girls: a randomized clinical trial. J Dent (Tehran). 2011;8(4):186–192.

97. Szöke J, Bánóczy J. Effect of xylitol on the microbiota of dental plaque. Acta Microbiol Immunol Hung. 2001;48(1):75–80. https://doi.org/10.1556/AMicr.48.2001.1.9

98. Van Loveren C. Sugar alcohols: what is the evidence for caries-preventive and caries-therapeutic effects? Caries Res. 2004;38(3):286–293. https://doi.org/10.1159/000077767

99. Mäkinen KK, Hujoel PP, Bennett CA, et al. Polyol chewing gums and caries rates in primary dentition: a 24-month cohort study. Caries Res. 1996;30(6):408–417. https://doi.org/10.1159/000262352johcd.net

100. Isokangas P, Mäkinen KK, Tiekso J, Alanen P. Long-term effect of xylitol chewing gum in the prevention of dental caries: a follow-up 5 years after termination of a prevention program. Caries Res. 1993;27(6):495–498. https://doi.org/10.1159/000261587johcd.net