

REVIEW

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Specific effects of xylitol chewing gum on mutans streptococci levels, plaque accumulation and caries occurrence: a systematic review

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Abstract

Objective A systematic review of published data was carried out to assess specific effects of xylitol chewing gum on levels of mutans streptococci (MS), dental plaque, or caries.

Materials and methods Electronic and hand searches were performed to find clinical studies on levels of MS, or plaque, or caries comparing effects of xylitol gum with a polyol control gum. Prospective randomized or controlled clinical studies published before 2025 were included in the review.

Results The search identified 908 titles on MS, 879 titles on plaque, and 658 on caries to be evaluated. After applying inclusion and exclusion criteria, 16 articles on MS, ten on plaque and five on caries were reviewed. In 12/14 studies xylitol gum significantly decreased MS counts compared with sorbitol gum. Plaque accumulation decreased in 6/10 studies and caries occurrence in 3/5 trials when xylitol gum was compared with sorbitol/sorbitol-containing gum. Three studies on MS and/or plaque accumulation had a maltitol gum control, but the results of the studies were conflicting.

Conclusions The best evidence of specific beneficial effects for xylitol gum differing from those of sorbitol gum are found in the evaluated MS and plaque studies. The results of the reviewed caries trials are in line with this idea. Xylitol gum chewing is suggested to act as an adjunct to toothbrushing for reducing caries-associated MS and plaque accumulation to control and prevent caries occurrence in children and adults. Adults with other plaque-related diseases like periodontal disease should also benefit from xylitol gum.

Keywords Xylitol, Sorbitol, Chewing gum, Mutans streptococci, Plaque, Caries

Introduction

Xylitol is a naturally occurring five-carbon polyol sweetener known for its beneficial effects on oral health, particularly when consumed in the form of chewing gum. Three systematic reviews have evaluated the effects of

xylitol on levels of MS (*Streptococcus mutans* and *S. sobrinus*) or *S. mutans* [1–3]. In two of them, the conclusion was that chewing xylitol gum reduced MS in comparison to a non-chewing control [1, 2]. The most recent systematic review evaluating clinical effects of sugar substitutes on MS concluded that consumption of low-intensity sweeteners, i.e., polyols like xylitol and sorbitol, helps to reduce cariogenic bacteria [3]. In these reviews the “chewing effect” was identified as an important confounding factor and no significant difference between

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the effects of xylitol vs. other polyols was reported. Additionally, in two systematic reviews evaluating the effects of xylitol chewing gum on plaque accumulation, the use of a non-chewing gum control group may have biased the conclusions in favor of xylitol [4, 5]. For example, in the review by Nasseripour et al. [5], the evaluated eight xylitol chewing gum studies all had a no gum control. Earlier systematic reviews on the effects of xylitol chewing gums on dental caries have resulted in great variation of conclusions [6–9]. The variation in the outcomes appears to be due to several factors, including highly restrictive inclusion criteria, variations in delivery methods and controls, and the inclusion of participants with no or very low caries incidence at baseline. A recent review suggested that the caries-reducing effect of adding xylitol chewing gum to the daily diet has been well demonstrated in children and adolescents with a high or moderate caries level [9]. This review employed relatively broad inclusion criteria and took into account the influence of participants' baseline caries levels on the study outcomes.

It is evident that xylitol and all other polyol sweeteners are better sweetener choices with regard to oral health compared to sucrose or fermentable carbohydrates in general. Xylitol, sorbitol, mannitol, maltitol and isomalt are the most commonly used polyols to be used as bulk sweeteners in sugar-free chewing gums. All polyol sweeteners, particularly when delivered via chewing gum, stimulate salivary flow, increasing the pH of the saliva and stopping “acid attacks” in dental plaque. Although the caries-preventive effects of polyol sweeteners are considered comparable [10], xylitol differs from other commonly used polyols—such as sorbitol, mannitol, maltitol, and isomalt—as it is composed of five carbon atoms, while the others are six-carbon compounds. This structural difference may have microbiological implications and should be reflected in clinical trial outcomes. Sugar-free chewing gums are recommended for example by the American Dental Association [11]. While these recommendations usually focus on reducing caries occurrence by chewing gum, sugar-free gum may also significantly benefit gingival health.

The conclusions of previous systematic reviews on xylitol are of clinical relevance, as they may influence recommendations made by healthcare professionals—specifically, whether to advise patients to use xylitol-containing chewing gum or any sugar-free gum. To our knowledge, no previous systematic reviews have specifically focused on the unique effects of xylitol as compared to other polyol sweeteners. This review aimed to address the following research questions: Do the effects of xylitol chewing gum on (1) MS levels, (2) plaque accumulation, or (3) caries occurrence differ from those of other

polyol-sweetened gums? In other words, are the effects specific for xylitol gum?

Materials and methods

This systematic review was conducted in accordance with the the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [12]. The review was registered in the International Prospective Register of Systematic Reviews (PROSPERO registration number CRD42024613332) before starting the data collection.

Information sources and research strategies

The research question for the present systematic review was formulated using PICO characteristics (Patients, Intervention, Control, Outcome), as follows: in children or adults (P), does the use of xylitol chewing gum (I), have specific effects, compared to other polyol gums (C), on reducing 1) levels of MS, 2) plaque accumulation, or 3) caries occurrence (O)?

The search to identify all the relevant, published studies was conducted using three databases: PubMed, Embase, and the Cochrane Library. Grey literature was searched on ClinicalTrials.gov. A hand search was conducted in the reference lists of previous systematic reviews close to the present topic. The authors have written two previous systematic reviews aiming to find out if xylitol chewing gum or candies/lozenges can reduce caries occurrence [9] or the accumulation of plaque [5]. We also wrote a systematic review on the effects of xylitol and erythritol consumption on the numbers of MS and composition of the oral microbiota [1]. In that review the abundant literature limited the search to cover papers published between 2000 and 2019. In the present review, we include only xylitol chewing gum studies with a polyol gum control to be able to focus on the specific effects of xylitol. The same broad search terms given in detail in the earlier three reviews were used to update the literature using the above three databases [1, 5, 9]. To search the literature published before 2000 on MS the PubMed and Embase databases were used. The searches were conducted in early November 2024 and checked for additional literature on January 3–5, 2025. The searches thus covered the years 1974–2024.

Study inclusion and exclusion criteria

As for clinical trials targeting counts of MS or the amount of plaque, only randomized controlled clinical trials (RCT) were accepted for evaluation. Of caries trials, prospective RCTs and controlled clinical trials (CCT) were included in the review. Moreover, only studies published in English were considered eligible. The aim of the included trials was to study the effect of xylitol chewing

gum on levels of MS, the accumulation of plaque, or caries occurrence. MS/plaque/caries could be either the primary or secondary outcome measures in the evaluated studies. Concerning all these outcome measures, the increment values had to be available (baseline and final/increment). In other words, the included studies compared baseline values with values obtained in the same subjects after the intervention period. The comparison/control was a polyol-sweetened chewing gum. The daily dose of xylitol had to be available to meet the inclusion criteria. Xylitol had to be the polyol with the highest concentration of all polyols in the product. The control product could contain no xylitol or only low levels of xylitol. Minimum duration of the intervention in the caries trials had to be 6 months, and 2 years for follow-up.

Exclusion criteria used when evaluating titles and abstracts: the study population consisted of patients under treatment or individuals with disabilities; dental caries/plaque/MS were not outcomes of the study; no polyol control; in vitro studies, reviews, comments or study protocols; the polyol vehicles were oral sprays or rinses, toothpastes, pacifiers, milk, wipes, or varnishes; the xylitol gums contained active components like fluoride, carbamide, or nicotine; mother-to-child MS transmission studies; the study was not available in English.

Exclusion criteria when evaluating full-text articles on MS: no control [13], MS assessment not specific for MS [14], no information on the daily dose of xylitol [15–18], the control gum was gum base [19]. Exclusion criteria in evaluation of full-text articles on plaque: no baseline values [20, 21], no information on the daily dose of xylitol [17, 18]. Exclusion criteria when evaluating full-text articles on caries: no control fulfilling the inclusion criteria [22, 23].

Study selection and data extraction

Screening of the records was performed after duplicate removal independently by the review team (KP, ES). ES and KP have been calibrated during the evaluation and analysis process of similar systematic reviews between 2020 and 2024. The review team members scanned the titles and, when needed, read the abstract. The team members independently decided which studies in their opinion fulfilled the criteria for full-text review.

The reviewers collected the data from the articles chosen for the full-text review. The following data were systematically extracted from each included article: author and year of publication, study site, number and age of participants, study design, intervention and controls, outcome measure, and main results. For articles on MS and plaque accumulation the assessment method was collected. As for caries trials, caries at baseline (when available) and the caries increment were collected. In case the

design in the evaluated caries trial included several xylitol subgroups, the subgroup with the longest duration was selected for the present analysis. In studies performed with high-concentration xylitol chewing gums with xylitol as the only sweetener vs. polyol mixture gums, the xylitol gum with the highest recommended consumption frequency was chosen for evaluation. For baseline caries and caries increment values, preferably indices measuring dentinal caries or localized enamel breakdown (corresponding to ICDAS 3–6 decay) were selected. As the measure of preventive effect, the reviewers calculated the prevented fraction (PF) based on reported results. PF was the proportion of caries reduction (= the caries increment in control group – the caries increment in intervention group) of the caries increment in the control group and expressed as a percentage. Any disagreements were resolved by discussion among the reviewers.

Assessment of methodological quality and risk of bias

Even though not all the selected trials were randomized, we used the Cochrane risk-of-bias tool for randomized trials (RoB 2) in the evaluation of the selected trials [24]. The reviewers independently evaluated the included full-length articles and, based on mutual agreement, eliminated discrepancies between each individual assessment.

The studies were appraised according to the following aspects: selection, performance, detection, attrition, and reporting bias. Each aspect was classified as having either low, high, or unclear risk of bias. The risk of bias evaluation was made separately for each outcome: MS counts, plaque accumulation, caries occurrence. Thus, a study with more than one outcome measure could be classified as a high/fair/low-quality study depending on the outcome. The bias was estimated to be unclear, for example, if the study did not evaluate the difference in changes between the xylitol vs. control group or the study was randomized but details on randomization were not given. Also, when information not found in the paper was received, by contacting the authors, the bias was classified as unclear. The overall level of risk for each study was classified as low (all quality items were met: high quality), unclear (unclear risk of bias for one or more domain: fair quality), or high (high risk of bias for one or more domain: low quality) [1, 5, 9, 24].

Results

Study selection

In the screening (2000-) for articles on MS, 677 articles were found (251 PubMed, 296 Embase, 130 Cochrane). The removal of duplicates left 354 articles for screening of titles/abstracts. 334 records were excluded, leaving 20 full-text articles for assessment of eligibility. After the exclusion of 7 articles for not meeting the eligibility

criteria, 13 articles were included in the final review. In the search targeting articles published before 2000, we found 231 articles for title and abstract screening (114 PubMed, 117 Embase). The removal of duplicates left 148 articles for screening of titles and abstracts. 145 records were excluded, resulting in three additional articles which met the inclusion criteria and were included in the evaluation. Thus, altogether 16 articles on MS were selected to be reviewed.

A total of 879 articles were screened for plaque, with sources from PubMed, Embase and Cochrane, resulting in 10 articles included for review. After removal of duplicates, 462 titles and abstracts were screened. 448 records were excluded, leaving 14 articles for full-text assessment. In the full text evaluation, four articles were excluded, which resulted in ten articles to be reviewed.

In the search for caries articles, a total of 658 titles were screened for relevance (214 PubMed, 274 Embase, 171 Cochrane). Exclusion of duplicates left 384 articles to be evaluated. Based on the information in the titles and abstracts, 377 articles were removed. In the full-text evaluation, two additional articles were removed, resulting in five articles to be reviewed.

Study characteristics

Studies on MS counts and the amount of plaque

The studies included in the review were prospective, randomized, controlled studies published between 1984 and 2017 [25–44]. In the 20 articles included in the review, all participants were classified as healthy by the authors of the studies. All but one study [25] reported the age of the participants (age range from 5 to 73 years), sample size (ranging from 10 to 176), and study duration (from 6 days to 1 year). The number of subjects refers to those subjects who completed the study within the groups of the present comparisons (Tables 1 and 2).

Caries trials

The five caries trials included in the review were either controlled clinical trials or randomized controlled trials published between 1995 and 2017 [40, 45–48]. In two studies, subjects with systemic diseases or antibiotic use [40, 48] were excluded from the study. In the rest of the trials, no health issues were reported. All studies reported the age of the subjects (age range from 6 to 45 years), sample size (ranging from 130 to 249), intervention (from 6 months to 3.3 years), and study duration (from 2 to 3.3 years). In all studies, the subjects were considered to be at moderate or high risk for caries (Table 3). Xylitol products were not replacing other sugar intake.

Quality assessment of the selected studies

Figure 1 summarizes the risk of bias in the 24 evaluated articles. The risk-of-bias assessments revealed that one MS trial had a low risk of bias [31], three studies had a high risk of bias [28, 30, 38], and the rest (12 studies) had an unclear risk of bias. Of the plaque trials one study had a low risk of bias [34], two studies [38, 44] were scored as having a high risk of bias, and the rest had an unclear risk of bias [26, 29, 41, 42 (a, b, c), 43]. The assessment of the caries trials revealed that one study was of high quality with a low risk of bias [40], two had an unclear risk of bias [47, 48], and two of the studies were scored as having a high risk of bias [45, 46].

Since the present review includes studies from the 80's and 90's, it is evident that strategies to deal with confounding factors, such as randomization or blinding were not stated. Apparently only in seven studies the randomization was made on an individual basis using computer-generated randomization [30, 31, 34, 35, 40, 44, 48]. In four studies the reported results were not supported by the findings resulting in reporting bias [29, 30, 38, 44]. In two of these studies the reported results in the abstract or conclusions were not supported by the findings [29, 30]. One study suffered from a high risk both in relation to reporting and attrition bias [38]. Attrition may be a problem especially in long-term caries trials. It was low in two studies, thus resulting in a low attrition bias [40, 48]. The attrition bias was unclear in three studies [45–47]. The high attrition in long-term caries trials can be offset by including those subjects who completed the study in the analyses and doing a proper dropout analysis. One of the older trials did not analyse the effect of the attrition, which led to an unclear risk of reporting bias [45] (Fig. 1).

Study outcomes

Studies on MS counts

In 12 of 14 studies comparing xylitol gum with a control sorbitol gum (or a sorbitol-containing polyol mixture gum), xylitol gum use significantly decreased MS counts compared to the control gum [25–32, 34–37, 39, 40] (Table 1). In most of these 12 studies no MS changes were reported for the sorbitol control groups; however, in two studies the MS levels increased [26, 27] and in one they decreased [39]. This suggests specific effects for xylitol on MS counts. In ten studies the xylitol chewing gum was a high-concentration xylitol gum, in two a polyol mixture gum [35, 40]. Significant decreases in MS counts were reported for both salivary [25, 26, 29–32, 34–37, 40] and plaque [25, 26, 29, 31, 32, 34, 36] MS levels. In 13 studies, the daily dose of xylitol was appr. 5 g or higher [25–32, 34–37, 39]. Seven of the 14 studies reported in the xylitol chewing gum group five-fold to ten-fold decreases in MS

Table 1 Summary of the included studies on effects of xylitol chewing gum on MS counts

	Subjects, n	Study design; outcome measure	Intervention	Control	Assessment method	Results
Loesche et al. (1984); Ann Arbor, USA	7–9-yr children, n=43 (MS log CFU > 4) and (DS + ds) ≥ 2	Double-blind, randomized, controlled study (4 wk), saliva and plaque <i>Streptococcus mutans</i> (pom)	XYL gum (XYL 59%, SOR 19%, 7.7 g/d*, 5xd)	SOR gum (SOR 36%, MAN 31%)	Plate culturing of <i>S. mutans</i>	Salivary <i>S. mutans</i> decreased at 2 and 4 wk, within the XYL group ($p=0.05$). Within the SOR group, no change was found. At 4 wk, the <i>S. mutans</i> level was lower in the XYL than the SOR group ($p=0.01$). The occlusal and approximal plaque <i>S. mutans</i> % decreased at 2 wk, within the XYL group ($p=0.05$). (ANOVA, paired t-test)
Söderling et al. (1989); Ann Arbor, USA	19–35-yr-old adults, n=14	Blinded**, randomized**, controlled study (2 wk), MS from plaque and saliva (som)	XYL gum (76%, 11 g/d, 5xd)	SOR gum (76%, 5xd)	Plate culturing of MS from plaque and Dentocult SM Strip mutans for MS from saliva	The plaque MS% and the salivary MS scores decreased in the XYL group, in the SOR group no changes or increases in MS; XYL/SOR comparison ($p<0.05$) (chi-square, paired t-test)
Wennerholm et al. (1994), Gothenburg, Sweden	19–37-yr-old adults, n=17 (MS log CFU > 5)	Double-blind, randomized, cross-over study (25 d), saliva MS (pom)	XYL gum (70%, 13.4 g/d, 1 2xd)	SOR gum (70%, 13.4 g/d, 1 2xd)	Plate culturing of MS from plaque and saliva	The final salivary MS was lower in the XYL than the SOR group ($p=0.001$). For plaque MS no significant differences between the groups. MS increased in SOR group ($p<0.01$). (paired t-test)
Twetman & Stecksén-Blicks (2003); Halmstad, Sweden	3–4-yr-old children, n=10 (ds ≥ 2)	Single-blind, rando-mized, controlled cross-over study (2 wk), saliva MS (som)	XYL gum (65%, 5 g/d, 3xd)	SOR gum (SOR, MAL: tot. 63%)	Dentocult SM Strip mutans	No change in the distribution of salivary SM scores in either group. No XYL/SOR comparison. (paired t-test)
Mäkinen et al. (2005); Daegu, South Korea	Appr. 5-yr-old children, n=84	Double-blind, rando-mized, controlled study (6 mo); MS from plaque and saliva (pom)	XYL gum (80%, 4.5–5 g/d, 5xd)	SOR gum (SOR 70%, MAL 10%, 5xd)	Plate culturing of MS (plaque), Dentocult SM Strip mutans (saliva)	A decrease in MS of plaque ($p<0.001$) and saliva ($p<0.001$) in the XYL group. No changes in the SOR groups. No XYL/SOR comparison. (Wilcoxon, paired t-test)
Ly et al. (2006); Seattle, USA	18–73-yr-old adults, n=132 (MS log CFU ≥ 4)	Double-blind, rando-mized, controlled trial (5 wk); plaque and saliva MS (pom)	XYL gum (65%, 10.3 g/d, 2/3/4xd)	SOR gum (SOR 64%, MAL 4%, 4xd)	Plate culturing of MS	At 5 wk, groups that chewed XYL gum 3x or 4xd showed lower unstimulated saliva and plaque MS counts compared to SOR group ($p<0.1$). (t-test, ANOVA)

Table 1 (continued)

	Subjects, n	Study design; outcome measure	Intervention	Control	Assessment method	Results
Milgrom et al. (2006); Seattle, USA	18–73-yr-old adults, n = 132 (MS log CFU ≥ 4)	Double-blind, rando-mized, controlled trial (6 mo); plaque and saliva MS (pom)	XYL gum (65%, daily dose 3.4, 6.9 or 10.3 g, 4xd)	SOR gum (SOR 64%, MAL 4%, 4xd)	Plate culturing of MS	The MS level was lower in the XYL groups (6.9 g and 10.3 g) than in the SOR group at 5 weeks (plaque; $p = 0.01$ and $p < 0.001$) and at 6 months (plaque; $p < 0.001$ and $p = 0.04$, and unstimulated saliva; $p = 0.01$ and $p = 0.04$). (t-test, ANOVA)
Caglar et al. (2007); Istanbul, Turkey	21–24-yr-old adults, n = 80	Double-blind, rando-mized, controlled study (3 wk); saliva MS (pom)	XYL gum (77%, 4 or 6 g/d, 2 or 3xd)	SOR gum (77%, 3xd)	Dentocult SM Strip mutans	Salivary MS scores decreased in the XYL group consuming 6g XYL 3xd ($p < 0.05$). No changes in the SOR group. XYL group differed from SOR group ($p < 0.05$). (chi-square)
Haresaku et al. (2007); Fukuoka, Japan	18–53-yr-old adults, n = 67	Double-blind, rando-mized, controlled study (6 mo); saliva and plaque MS (pom)	XYL gum (78%, 7.9 g/d, two gums after every meal)	MAL gum (MAL 75%, XYL 4.7%, two gums after every meal)	Plate culturing of MS	MS decreased in plaque ($p < 0.001$) and saliva ($p < 0.05$) in the XYL group. No change (saliva) or increase (plaque, $p < 0.001$) in MAL group. The changes in plaque MS within the XYL and MAL groups differed ($p < 0.001$). (ANCOVA, Dunnett test)
Holgerson et al. (2007); Sävar, Sweden	7–12-yr-old children, n = 128	Double-blind, rando-mized, controlled study (4 wk); saliva MS (pom)	XYL gum (77%, 6.2 g/d, 3xd)	SOR gum (SOR 64%, MAL 5%, 3xd)	Plate culturing of MS	Salivary MS decreased in caries-free children ($p < 0.05$) and the plaque MS% in all children ($p < 0.01$) in the XYL group. No changes in the SOR group. Difference between groups in plaque MS% at 4 weeks ($p < 0.05$). (t-test, ANOVA)
Campus et al. (2009); Sassari, Italy	7–9-yr-old children, n = 176 (high caries risk, MS log CFU > 5)	Double-blind, rando-mized, controlled study (6 mo); saliva MS (som)	XYL gum (XYL 37%, SOR 18%, MAL 10%, MAN 7%, 11.6 g/d, 5xd)	Isomalt gum (isomalt 30%, SOR 18%, MAL 16%, MAN 7%, 5xd)	Plate culturing of MS	Salivary MS decreased at 3 ($p = 0.04$) and 6 mo ($p = 0.02$) in the XYL group. No changes in the ISOM group. The XYL group differed from the ISOM group at both 3 and 6 mo ($p < 0.05$). (ANOVA)
Söderling et al. (2011); Oulu, Finland	28–38-yr-old adults, n = 12	Double-blind, rando-mized, controlled crossover study (4 wk); plaque and saliva MS (som)	XYL gum (65%, 6 g/d, 3xd)	SOR gum (SOR 63%, MAL 2%, 3xd)	Plate culturing of MS	Plaque MS% decreased in the XYL group ($p < 0.001$). No changes in the SOR group. No changes in the saliva MS. No XYL/SOR comparison. (paired t-test, ANOVA)

Table 1 (continued)

	Subjects, n	Study design; outcome measure	Intervention	Control	Assessment method	Results
Bahador et al. (2012); Tehran, Iran	20–28-yr-old dental students, n = 24	Double-blind, rando-mized, controlled, cross-over study (3 wk); salivary MS (pom)	Xylitol chewing gum (70%, 6.6 g/d, 3xd)	SOR gum (63%, 3xd)	Plate culturing of MS	<i>S. mutans</i> ($p < 0.01$) and <i>S. sobrinus</i> ($p < 0.05$) decreased in the XYL group, but not in the SOR group. XYL group differed from SOR ($p < 0.05$). (ANOVA)
Thabuis et al. (2013); YIXing, China	13–15-yr-old children, n = 134	Double-blind, rando-mized, controlled study (30 d); plaque amount (som)	XYL gum (59%, 10 g/d, 5xd)	MAL gum (59%, 5xd)	Plate culturing of MS	XYL and MAL gums decreased plaque MS counts. The magnitude and significance of the decreases not reported. (ANOVA)
Söderling et al. (2015); Kuwait	11–12-year-old boys, n = 73 (MS log CFU > 5)	Double-blind, rando-mized, controlled study (5 wk); saliva MS (pom)	XYL gum (65%, 6 g/d, 3xd)	SOR gum (SOR 63%, MAL 2%, 3xd)	Plate culturing of MS	A decrease in salivary MS in the XYL group ($p < 0.01$) and the SOR group ($p < 0.05$). No XYL/SOR comparison. (paired <i>t</i> -test)
Cocco et al. (2017); Sassari, Italy	30–45-yr-old adults, n = 143 (high caries risk, MS log CFU > 5)	Double-blind, rando-mized, controlled trial (1 yr); saliva MS (som)	XYL chewing gum (XYL 30%, SOR 26%, MAN 11%, MAL 1%, XYL 2.5 g/d, 3xd)	SOR gum (SOR 31%, isomalt 28%, MAN 9%, MAL 1%, 3xd)	Plate culturing of MS	Salivary MS decreased at 12 mo ($p < 0.01$), in the XYL group. No change in the SOR group. At 12 mo salivary MS was lower in the XYL than the SOR group ($p = 0.03$). (ANOVA)

XYL xylitol, SOR sorbitol, MAL maltitol, MAN mannitol, ISOM isomalt, MS mutans streptococci, CFU colony-forming units, ds decayed surfaces, d days, wk weeks, mo months, yr years, pom primary outcome measure, som secondary outcome measure, *information obtained from Prof. Kauko K. Mäkinen, **information obtained from the authors, ANOVA analysis of variance, ANCOVA analysis of covariance

Table 2 Summary of the included studies on effects of xylitol chewing gum on the amount of plaque

Subjects; n	Study design; outcome measure	Intervention	Control	Assessment method	Results
Söderling et al. (1989); Ann Arbor, USA	19–35-yr-old adults, n = 14 Blinded*, randomized*, controlled study (2 wk); plaque amount (pom)	XYL gum (76%, 11 g/d, 5xd)	SOR gum (76%, 5xd)	Fresh weight NOH 2 d	The plaque decreased in the XYL group and increased in the SOR group; the change-related difference between the groups significant ($p = 0.025$). (Paired <i>t</i> -test, rank sum test)
Steinberg et al. (1992); New York, USA	Adults, n = 28 Double-blind, randomized, controlled crossover study (6 wk); plaque amount (pom)	XYL gum (1.8g/stick*, 9g/d*, 5xd)	SOR gum (1.8g/stick, 5xd), no gum	Quigley-Hein PI NOH 0.5 d	In the XYL ($p < 0.001$) and SOR ($p < 0.05$) groups plaque decreased. No difference between XYL and SOR groups. (Paired <i>t</i> -test)
Cronin et al. (1994a); New Jersey, USA	> 18-yr-old adults, n = 59 Blinded, randomized, controlled study (2 wk); plaque amount (pom)	XYL gum (0.8g XYL, 0.2g SOR/piece, 8g/d, 5xd)	SOR gum (5xd)	Fresh weight NOH 2.5 d	Plaque regrowth was reduced more by the XYL gum compared to the SOR gum ($p < 0.05$). (Two-sided <i>t</i> -test)
Cronin et al. (1994b); New Jersey, USA	> 18-yr-old adults, n = 154 Double-blind, randomized, controlled trial (2 wk); plaque amount (pom)	XYL gum (0.8g XYL, 0.2g SOR/piece, 4.6–8g/d, 3xd, 4xd, 5xd)	SOR gum (5xd)	Fresh weight NOH 2.5 d	Plaque regrowth was reduced more by XYL gum compared to SOR gum ($p < 0.05$). (ANCOVA)
Cronin et al. (1994c); New Jersey, USA	> 18-yr-old adults, n = 142 Double-blind, randomized, controlled study (2 wk); plaque amount (pom)	XYL pellet gum (850 mg/piece, 8.5g/d, 5xd), XYL stick gum (850 mg/stick, 4.3 g/d, 5xd)	SOR gum (5xd)	Fresh weight NOH 2.5 d	Plaque regrowth was reduced more by the XYL gums compared to the SOR gum ($p < 0.01$). (ANCOVA)
Tellefsen et al. (1996); Linda, USA	21–35-yr-old adults, n = 14 Double-blind, randomized, controlled crossover study (6 d); plaque amount (pom)	XYL gum (0.8g/piece, 4g/d, 3xd)	SOR gum (1 g/piece, 3xd)	Quigley-Hein PI NOH 6 d	XYL gum reduced plaque regrowth more than SOR gum ($p < 0.01$). (ANOVA for repeated measures)
Mäkinen et al. (2005); Daegu, Korea	5-yr-old children, n = 84 Double-blind, randomized, controlled trial (6 mo); plaque amount (pom)	XYL gum (80%, 4.5–5g/d, 5xd)	SOR gum (73%, 5xd)	Quigley-Hein PI on buccal surfaces of all deciduous teeth present NOH not reported	XYL gum decreased plaque PI scores ($p = 0.04$), no change in the SOR gum group. No XYL/SOR comparison reported. (Wilcoxon signed ranks)
Holgerson et al. (2007); Sävar, Sweden	7–12-yr-old children, n = 128 Double-blind, randomized, controlled study (4 wk); plaque amount (pom)	XYL gum (77%, 6.2g/d, 3xd)	SOR gum (SOR 64%, MAL 5%, 3xd)	Simplified oral debris index on buccal sites of six teeth. NOH not reported	XYL and SOR gums decreased plaque compared to baseline ($p < 0.05$). No difference between the groups at 4 wk. (Chi square)

Table 2 (continued)

	Subjects; n	Study design; outcome measure	Intervention	Control	Assessment method	Results
Thabuis et al. (2013); YIXing, China	13–15-yr-old children, n = 134	Double-blind, randomized, controlled study (30 d); plaque amount (som)	XYL gum (59%, 10 g/d, 5xd)	MAL gum (59%, 5xd)	Quigley-Hein PI NOH 2 d	XYL and MAL gums decreased plaque. The magnitude of the decreases not reported. (ANOVA)
Keukenmeester et al., (2015); Amsterdam, the Netherlands	> 18-yr-old adults, n = 111 (moderate gingivitis)	Double-blind, randomized, controlled study (3 wk); plaque amount (som)	XYL gum (64%*, 9 g/day*, 5xd)	MAL gum (64%*, 5xd)	Quigley-Hein PI NOH 0.5 d	XYL and MAL gums decreased plaque in the brushed upper jaw ($p < 0.001$). No XYL/MAL comparison reported. Increase in plaque in the nonbrushed lower jaw ($p < 0.001$). (Kruskal-Wallis, Wilcoxon)

XYL xylitol, SOR sorbitol, MAL maltitol, PI plaque index, MS mutans streptococci, wk weeks, yr years, mo months, d days, pom primary outcome measure, som secondary outcome measure, NOH no oral hygiene. *details on the study obtained from the authors, ANOVA analysis of variance, ANCOVA analysis of covariance

Table 3 (continued)

Subjects, n	Study design	Intervention	Control	Outcome measure	BL caries	Caries increment	Prevented fraction	Results
Mäkinen et al. 1996; Stann Creek, Belize 6-yr-old children, n = 249	Controlled, double-blind cohort study, 2 yrs.; caries pom	XYL pellet gum (60.5%) and XYL stick gum (65%), 10 g/d, 5xd	SOR pellet (65%) and SOR stick (61%) gum, 5xd	Average transition frequencies from sound to dmfs	XYLp/SORp: 12.2/10.5 XYLs/SORs: 11.0/12.8	XYLp/SORp: 1.8/2.4 XYLs/SORs: 2.6/3.7	XYLp/SORp: 25% XYLs/SORs: 30%	The caries reductions in the XYLp and XYLs groups did not differ from the corresponding SORp and SORs groups ($p = 0.15$ and $p = 0.49$). (Poisson regression model)

XYL xylitol, SOR sorbitol, MAL maltitol, MAN mannitol, ISOM isomalt, p pellet gum, s stick gum, yr year, yrs years, mo months, d days, pom primary outcome measure, DMFT, DMFS, dmfs, DFS the number of decayed (D/d), missed (M/m) and filled (F/f) teeth (T) or surfaces (S) for permanent/deciduous teeth, BL baseline, ANOVA analysis of variance

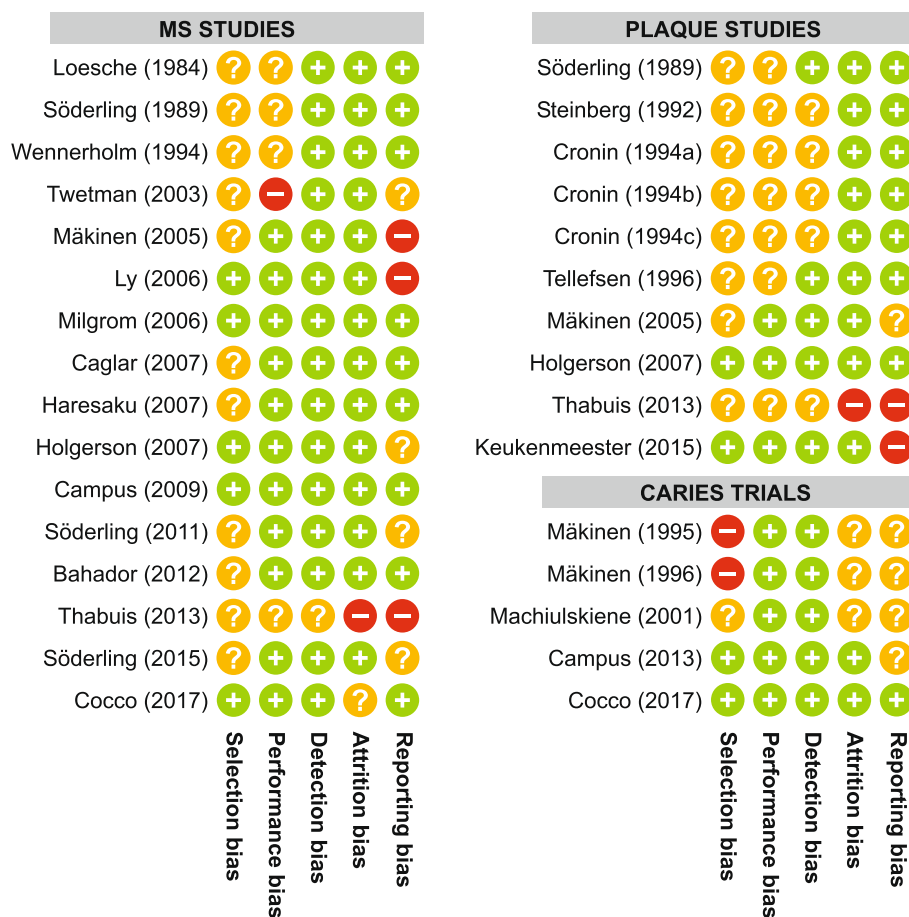


Fig. 1 Risk of bias summary. The risk of bias has been evaluated separately for each outcome

levels, which may be regarded as clinically significant [25, 29–31, 34, 37, 39]. The oldest study by Loesche et al. [25] reported a ten-fold (90%) decrease in salivary MS in the xylitol group. Ten-fold decreases in MS counts of plaque MS at five and six months were also reported in the high-quality trial by Milgrom et al. [31]. The study compared the effects of three daily xylitol doses, finding no effect for the lowest dose (3.4g/day) and a plateau effect between 6.4 and 10.3g of xylitol per day [31]. The five-week study by Ly et al. [30] suggested that the consumption frequency of xylitol gum should be three times or higher per day for MS-reducing effects. Interestingly, in two semiquantitative studies the individual changes in salivary MS scores revealed that in more than half of the subjects the MS scores showed ten-fold or higher decreases, but some of the subjects showed no MS changes [26, 32]. This suggests that the susceptibility of MS to xylitol exposure may vary on individual level. In the Cocco et al. [40] one-year study, high-caries-risk adults consumed a rather low daily dose of xylitol, 2.5g/day. A small but significant decrease was observed in salivary MS counts

in the xylitol group, and at the one-year examination the MS counts were lower than in the sorbitol group. In three studies the decreases in MS counts were rather small [27, 35, 36].

In two of the 16 evaluated MS studies xylitol gum was compared with a maltitol gum [33, 38]. The good quality Haresaku et al. study [33] reported a significant decrease in MS counts of both plaque and saliva in the xylitol group, while no change (saliva MS) or increase (plaque MS) took place in the maltitol control group. In the 30-day low-quality study by Thabuis et al. [38], a decrease in plaque MS counts was reported for both groups, however; the magnitude and significance of the decreases were not reported.

Studies on the amount of plaque

In six of the 10 included studies, xylitol gum chewing significantly decreased plaque accumulation compared to the sorbitol control gum [26, 29, 42 (a, b, c), 43] (Table 2). This suggests specific effects for xylitol also on plaque accumulation. In a 2-week study, xylitol chewing gum

decreased the fresh weight of plaque by 29%, while an increase in plaque was seen in the sorbitol gum group [26]. All seven subjects of this small study showed a decrease in the amount of plaque in the xylitol group. The three 2-week substudies by Cronin et al. [42 (a, b, c)] compared, among other things, the effects of various daily doses of xylitol on fresh weights of plaque in association with consumption of xylitol/sorbitol and sorbitol gum. In these studies, plaque regrowth was reduced by 23–38% in the xylitol gum groups. In the sorbitol control groups, the plaque regrowth reductions were small, 8–10%, and differed significantly from the reductions in the xylitol group [42]. In the 6-month study by Mäkinen et al. [29], xylitol gum chewing decreased the mean plaque index of five-year-old children by 8% while no change was seen in the sorbitol control group. The chewing gum study by Tellefsen et al. [43] evaluated plaque regrowth using a mean plaque index after 6 days of no oral hygiene combined with xylitol or sorbitol gum chewing, xylitol gum reducing regrowth by 37% when compared to sorbitol gum. In the remaining four studies both the xylitol gum and the control polyol gums showed similar decreases in plaque accumulation [34, 38, 41, 44] (Table 2).

Caries trials

The five evaluated xylitol chewing gum studies were all carried out in high caries level subjects and analyzed a total of 921 subjects. Three of these five studies reported a statistically significantly better caries preventive effect for xylitol gum in comparison with the placebo polyol gum [40, 45, 48]; PF varied from 31 to 119% (Table 3). In the Mäkinen trial [45], the present comparison could be carried out between xylitol and sorbitol gums (pellets). The PF was 119% for xylitol gum when compared with sorbitol gum. The Campus et al. [48] trial was a well-planned study with a 2-year follow-up and an intervention period of 6 months. The study design included comparison of xylitol and a mixture of isomalt, sorbitol, and mannitol. The PF was 86%: in the xylitol group there was practically no increase in the proportion of children with dental decay or fillings in permanent first molars; in the polyol mixture group, the respective increase was considerable. The Cocco et al. [40] trial was the only high-quality study analyzed. It compared a xylitol-polyol mixture with a sorbitol-polyol mixture and was carried out in adults. The intervention lasted one year and the follow-up was two years. The PF was 31%: the increment of total caries experience was lower in the xylitol gum group than in the sorbitol group.

In two of the five studies analyzed, xylitol gum did not significantly differ from the control sorbitol gum in relation to caries-preventive effect [46, 47]. In the

Machiulskiene et al. [47] trial, this comparison could be carried out between xylitol and sorbitol gum. The PF was 26%, however, this difference was not significant. In the Mäkinen et al. [46] trial the comparisons could be done between xylitol and sorbitol sticks and between xylitol and sorbitol pellets. This was the only evaluated study to report the results for deciduous dentition. The caries increments in the xylitol groups were lower than in the sorbitol groups. The PF was 25% for pellets and 30% for sticks; the difference in the effect was, however, not significant [46] (Table 3).

Adverse effects

In six of the 16 evaluated studies on effects of xylitol and control chewing gums on MS counts possible adverse effects were recorded and reported [29, 32, 35, 38–40]. In six of the 10 plaque studies, adverse effects had been recorded [29, 38, 42 (a, b, c), 44], and for the caries studies the corresponding figure was three of altogether five trials [40, 45, 48]. Only in one of the substudies of Cronin et al. [42c], one subject discontinued the study based on feeling nauseous due to gum chewing (group not reported). No other adverse effects were reported in the xylitol chewing gum studies included in this review.

Discussion

Beneficial effects on dental caries and two caries risk indicators, MS and dental plaque, were shown for xylitol chewing gum consumption but not for sorbitol gum. Sorbitol gum was the polyol control gum in the majority of evaluated studies. The best evidence of specific “xylitol-effects” was found in the evaluated MS studies. The review revealed that xylitol chewing gum consumption reduced MS counts while no such effect was found for the sorbitol chewing gum control. Also, the studies on plaque accumulation supported the idea of specific effects of xylitol chewing gum. The results of the few evaluated caries trials were in accordance with this idea. The fact that the results of the MS, dental plaque, and caries studies are all in line with each other gives support to the idea that xylitol gum has specific effects.

In 12 of the 14 studies in which xylitol gum was compared with sorbitol gum, a decrease was reported in the MS or *S. mutans* levels in the xylitol chewing gum group which differed from the changes in the control sorbitol gum group [25–27, 29–32, 34–37, 40]. Only in one of the 14 studies did the control sorbitol gum decrease MS counts [39]; in the rest of the studies either an increase [26, 27] or no change was reported. This result supports the idea of specific effects of xylitol gum on MS counts. Nine of the 14 studies reported in the xylitol chewing gum group several-fold, even more than ten-fold, decreases in MS levels, which may be regarded as

clinically significant [25, 26, 29–32, 34, 37, 39]. Even high MS levels are no indicators of high caries risk as such, but will be if there is a negative shift in oral hygiene or diet, or if the saliva flow rate is reduced. Caries can occur without MS but in the presence of MS caries is more aggressive [49, 50]. The presence and especially high levels of MS in the dentition is a risk factor of early childhood caries and future caries experience in preschool children in general [50, 51]. Thus, preventing or decreasing early MS colonization is important. Xylitol chewing gum consumption has in several studies decreased vertical transmission of MS [52, 53] which was associated with decreased caries occurrence in the primary dentition [54, 55].

In eight of the ten evaluated studies on plaque accumulation, xylitol chewing gum was compared with a control sorbitol gum [26, 29, 34, 41, 42 (a, b, c), 43]. In six of the eight studies xylitol gum chewing significantly decreased plaque compared to the sorbitol gum [26, 29, 42 (a, b, c), 43]. In five of the six studies the magnitudes of plaque reductions may be considered clinically significant [26, 42 (a, b, c), 43]. Thus, our results suggest that xylitol gum may have specific plaque-reducing effects compared with sorbitol gum. Plaque accumulation is regarded to be a true risk factor of both caries and periodontal disease. A decrease in plaque accumulation should benefit subjects of all ages. As an example of such a study dentate older individuals regularly chewed xylitol chewing gum, resulting in a decrease in plaque accumulation and improvement of self-perceived oral health [56].

Only three studies on MS and/or plaque accumulation had a maltitol gum as the control gum; thus, conclusions about the results are difficult to make. The results were also in disagreement: the fair-quality study by Haresaku et al. [33] showed a decrease in MS counts for xylitol gum, but no change in the maltitol gum group. On the other hand, a decrease in MS was reported in the xylitol and maltitol groups in the low-quality study by Thabuis et al. [38]. Two low-quality studies showed a decrease in plaque accumulation in both groups [38, 44]. Maltitol has a sweetness profile comparable to sucrose and is a common sweetener of chewing gums, however, only a few well-designed maltitol chewing gum trials have been published. A high-quality study by Prosdocimi et al. [57] conducted in individuals with active caries, found that maltitol chewing gum compared to gum base had minor effects on the composition of the plaque microbiome, including mutans-group streptococci. The results of the study are thus in agreement with those of Haresaku et al. [33]. Clearly, there is a need for more research on this topic.

The results of the five caries trials were in line with the results on MS and plaque accumulation. These five studies were, however, very heterogenous and thus difficult

to compare. Two of the studies were from the 2010s and supplied the best evidence for specific effects of xylitol gum [40, 48]. These two studies actually assessed whether xylitol gum had any specific caries-preventive effect compared to a sorbitol/sorbitol-containing gum and these studies did not have any “no-gum” control group for estimation of overall preventive effect of gum usage.

In the two Belize trials the participants were children with high caries level, poor oral hygiene and a diet high in sucrose [45, 46]. The daily doses of xylitol and sorbitol were rather high, 9–10 g/day. In the first trial by Mäkinen et al. [45], sorbitol gum chewing did not decrease caries compared to the no-gum group, while xylitol gum decreased caries compared both to the no-gum and the sorbitol gum group. In the second trial concerning deciduous dentitions, both xylitol and sorbitol gum decreased caries occurrence when compared to the no-gum group. However, the difference between xylitol and sorbitol groups was not significant [46]. Also, in the trial by Machiulskiene et al. [47], significantly lower caries increments were reported for the xylitol gum group compared to the no-gum group, but the difference between xylitol and sorbitol gum was not significant. In caries trials in which sorbitol gum has been compared to no treatment both no effects [58] and decreases [59] in caries occurrence have been reported. Interestingly, in a recent review, the authors concluded that both xylitol and sorbitol prevented dental caries [7]. However, the meta-analysis actually suggested that xylitol chewing gum prevented caries better than sorbitol gum [7], which is in accordance with our results. Even though the evaluated five caries trials were heterogenous, it is clear that also from a caries-prevention point of view, recommending xylitol gum is justifiable.

In comparison with MS levels and plaque accumulation the slow development of clinical signs of caries is the main problem in measuring dental caries. Therefore, the design of a clinical study as well as the control of confounding factors are challenging. All the evaluated caries trials were carried out in participants with a high caries risk and the follow-up time was long enough to enable the planned comparisons. The set-ups of the studies differed, however, very much in relation to age of subjects, dentition examined, dental care available and the daily dose of xylitol, which makes the interpretation of outcomes difficult.

Microbiological differences may best explain the differences between results of clinical trials with xylitol and sorbitol, even though some studies have suggested specific remineralization-promoting properties for xylitol [60]. The caries-preventive effects of xylitol are often connected with a decrease in the amount of MS, making the dental biofilm less cariogenic [1, 2]. As early as in

the 70's it was demonstrated that xylitol inhibits growth of planktonic MS. However, habitual xylitol consumption was suggested to select for so-called xylitol-resistant MS, not inhibited by xylitol [61]. These MS were suggested to be easily shed to saliva and be connected with a decrease in the accumulation of plaque [61]. This idea has not been supported by studies showing that xylitol chewing gum use reduces MS levels and plaque accumulation even in long-term use [29, 33, 35, 40, 62]. The degree of xylitol sensitivity also varies a lot among *S. mutans* strains, and in comparisons of xylitol-resistant versus xylitol-sensitive *S. mutans* strains, no differences in cariogenic traits were found [63, 64].

Apart from xylitol, systematic MS decreases have not been reported for other polyols used in chewing gums [1, 2, 10]. Xylitol is not fermented by oral microorganisms, including MS, and no adaptation to ferment xylitol has been reported [65, 66]. Chewing sweet xylitol gum stimulates the flow of saliva increasing its remineralizing properties without a pH drop in dental plaque. This effect contributes also to the overall caries-preventive effect of xylitol chewing gum. Sorbitol, on the other hand, as well as maltitol, frequently used in chewing gums, are slowly fermented by oral microorganisms [65, 66]. Repeatedly exposing *S. mutans* to these polyols has led to adaptation, i.e., increased fermentation [65, 66]. It has also been suggested that the effect of xylitol on polysaccharide production of MS could also contribute to the MS decreases found in clinical studies [1, 2]. Recently, it was demonstrated that xylitol modified the expression of polysaccharide-producing genes associated with the matrix composition of the adhesive biofilm of *S. mutans* [67]. Interestingly, xylitol has inhibited polysaccharide matrix formation by *Pseudomonas aeruginosa*, even though its growth is not inhibited by xylitol [68]. These mechanisms should also contribute to the reductions in plaque accumulation and caries occurrence reported for xylitol chewing gum in the present review.

Xylitol is not retained to the oral cavity after chewing, which may explain the apparent dose-response in the beneficial effects of xylitol on oral health. Prevention of plaque-related diseases with xylitol may not demonstrate a good cost-benefit ratio if the intervention is not used selectively for populations at higher risk. Using xylitol chewing gum as self-care should benefit all individuals with a high caries risk regardless of their age. The main targets of xylitol recommendations by health professionals may, however, be prevention-motivated adults with a high caries risk, like patients with aggressive caries, e.g. with active incipient caries lesions on buccal or lingual surfaces of teeth, xerostomic patients, and elderly people in general. Also motivated adults with a history of caries and young children may reduce the early

MS-transmission by consuming xylitol chewing gum. Daily xylitol doses of 5–6 g with a consumption frequency of three times a day appear to be effective in reducing MS counts, accumulation of plaque, and caries occurrence (Tables 1, 2, and 3 [22, 30, 31]). The recommended daily xylitol doses are not high, the dose is achieved with 5–6 pellet gums with a high xylitol concentration. However, the consumption frequency recommendations, 3 times a day or more, may make xylitol prevention arduous especially in children and adolescents. Several Dental Associations all around the world recommend xylitol, among others the Canadian Dental Association [69] which states that “Xylitol chewing gum can be especially helpful as it outperformed other sweeteners for its oral health benefits in clinical studies of caries prevention and reducing plaque”. The Finnish Current Care Guidelines 2023 for controlling caries [70] recommend xylitol 5–6 g/day to control caries occurrence. The recommendation is the same to parents with a history of dental caries in order to prevent MS transmission to their young children. In our opinion, there is good evidence supporting oral health benefits of chewing xylitol gum. However, the effects of other xylitol delivery vehicles on caries or caries-risk indicators need still more research. Most of the caries trials with xylitol have been done in children. Properly conducted and controlled clinical caries trials in high-caries-risk children would, however, be welcome. As for adults with caries, xerostomic patients and elderly people there is a clear demand for high-quality studies with both caries-risk indicators as well as caries as the outcomes.

Since the 1970s, xylitol studies have been mainly focused on caries occurrence or its risk factors, such as MS counts or plaque accumulation. Decreases in MS counts, MS adhesion, or plaque acidogenicity are factors associated with the suppressed cariogenicity of plaque. These factors are, however, also important and relevant with regard to periodontal disease. Xylitol chewing gum, which is suitable for self-care, can be recommended not only to patients with a high caries risk, but also to patients who suffer from gingival inflammation or periodontal disease. Xylitol chewing gum is no substitute for tooth brushing, however; any adjuncts which may support mechanical control of pathogenic biofilms and thus the prevention of periodontal disease are of importance. So far, only a few clinical trials have focused on periodontal applications of xylitol chewing gum [71]. Very recently, a novel application of xylitol chewing gum was presented by Valentine et al. [72]. According to the study results, Malawian pregnant women who chewed xylitol gum experienced fewer miscarriages compared to those who did not chew gum. This result was attributed to an improvement in periodontal health. The association between adverse pregnancy outcomes and periodontal

health has been demonstrated in several studies [72, 73]. Considering the high rates of miscarriages in Malawi, xylitol gum chewing could help to reduce the risk of periodontal disease-associated pregnancy complications.

In general, the only adverse effects connected with polyol consumption are digestive disorders. Xylitol and other polyols belong to FODMAP (fermentable oligo-, di-, monosaccharides and polyols) substances which may not be suitable for persons with digestive disorders. For dental benefits relatively small daily doses are recommended. Complaints about digestive discomfort in xylitol studies are rare [1, 5, 9], which is supported by results of the present review. When ingested in the form of chewing gum xylitol is absorbed from the gut and metabolized by efficient metabolic pathways [74]. Recently, the study by Witkowski et al. [75] suggested that xylitol is associated with increased cardiovascular risk. The study measured plasma xylitol, a naturally occurring intermediate of the pentose phosphate pathway, which is upregulated in subjects with, among other things, underlying metabolic disease. The subjects of the study suffering from health problems like diabetes and obesity did not participate in any xylitol intervention, the elevated plasma xylitol levels were associated with their health status. The only xylitol intervention in the study [75] took place in a substudy which consisted of ten subjects ingesting a water solution containing 30 g of xylitol. The resulting diarrhea supposedly was associated with the immediate changes in the plasma composition connected with cardiovascular risk.

We found 16 MS studies, 10 plaque studies, and five caries trials that met the inclusion criteria of the review. Surprisingly, considering that some of the studies were rather old, 17 of 24 articles showed a high or fair quality. A meta-analysis might have improved the review. A meta-analysis would have been difficult to perform and interpret, since the studies were heterogeneous with respect to subjects, methods, and study designs. A strength of the review is, however, that the included studies compared baseline or no-treatment values with values obtained after the intervention period, decreasing a possible risk of bias. In addition, our review included subjects who had no problems with their general health. Only studies carried out in healthy subjects are considered valid for making claims regarding beneficial oral health effects.

Conclusion

The findings of the present review suggest that clinically significant decreases in the caries-associated MS can be obtained by adding xylitol chewing gum to the daily diet. The present review also suggests that it is likely that habitual use of xylitol chewing gum decreases plaque accumulation, a risk factor of both caries and periodontal disease. These effects are specific to xylitol chewing

gum and differ from those of sorbitol chewing gum. The results of the few evaluated caries trials were in line with or at least did not contradict this idea.

Xylitol chewing gum can be helpful in the prevention and control of plaque-related diseases in children and adults. It is no substitute for tooth brushing, but an effective addition to daily health routines, i.e. tooth brushing with fluoride toothpaste and restriction of sucrose intake. Even though the present evaluation finds specific effects for xylitol chewing gum compared to sorbitol gum, the clinical impact of xylitol gum chewing may need further, well-controlled studies to be conclusive.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12903-025-06602-1>.

Supplementary Materials 1.

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Data availability

The data will be available on request from the corresponding author.

Authors' contributions

Both authors participated in the screening of records and evaluation of articles. ES wrote the main manuscript, and KP wrote all paragraphs concerning caries. ES prepared the figure and the tables. Both authors critically reviewed and edited the manuscript.

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Declarations

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