Preventing Dental Caries in Children <5 Years: Systematic Review Updating USPSTF Recommendation

abstract

BACKGROUND AND OBJECTIVE: Screening and preventive interventions by primary care providers could improve outcomes related to early childhood caries. The objective of this study was to update the 2004 US Preventive Services Task Force systematic review on prevention of caries in children younger than 5 years of age.

METHODS: Searching Medline and the Cochrane Library (through March 2013) and reference lists, we included trials and controlled observational studies on the effectiveness and harms of screening and treatments. One author extracted study characteristics and results, which were checked for accuracy by a second author. Two authors independently assessed study quality.

RESULTS: No study evaluated effects of screening by primary care providers on clinical outcomes. One good-quality cohort study found pediatrician examination associated with a sensitivity of 0.76 for identifying a child with cavities. No new trials evaluated oral fluoride supplementation. Three new randomized trials were consistent with previous studies in finding fluoride varnish more effective than no varnish (reduction in caries increment 18% to 59%). Three trials of xylitol were inconclusive regarding effects on caries. New observational studies were consistent with previous evidence showing an association between early childhood fluoride use and enamel fluorosis. Evidence on the accuracy of risk prediction instruments in primary care settings is not available.

CONCLUSIONS: There is no direct evidence that screening by primary care clinicians reduces early childhood caries. Evidence previously reviewed by the US Preventive Services Task Force found oral fluoride supplementation effective at reducing caries incidence, and new evidence supports the effectiveness of fluoride varnish in higher-risk children. *Pediatrics* 2013;132:332–350

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KEY WORDS

Dental caries, children, screening, treatment, prevention, fluoride, fluorosis, xylitol, education, counseling

ABBREVIATIONS

dmfs—decayed, missing, or filled tooth surfaces
OR—odds ratio
USPSTF—US Preventive Services Task Force

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Dental caries is an infectious process involving breakdown of the tooth enamel.[1,2] It is the most common chronic disease of children in the United States, and is increasing in prevalence among 2- to 5-year-olds.[3–5] Approximately three-quarters of children with caries have not received treatment.[5]

Early childhood caries is associated with pain and tooth loss, as well as impaired growth, decreased weight gain, and negative effects on speech, appearance, self-esteem, school performance, and quality of life.[2,6,7] Dental caries disproportionately affects minority and economically disadvantaged children.[5] Risk factors for dental caries include high levels of colonization by cariogenic bacteria, frequent exposure to dietary sugar and refined carbohydrates, inappropriate bottle feeding, low saliva flow rates, developmental defects of tooth enamel, previous caries, lack of access to dental care, low community water fluoride levels, inadequate tooth brushing or use of fluoride-containing toothpastes, lack of parental knowledge regarding oral health, and maternal risk factors, including caries, high levels of cariogenic bacteria, or poor maternal oral hygiene.[4,8,9]

Screening for dental caries before school entry could lead to interventions to treat existing caries at an earlier stage and prevent future caries. Young children often see a primary care medical provider starting shortly after birth, but do not see a dentist until they are older, suggesting an important primary care role for caries prevention.[10,11] Access to dental care is limited by many factors, including lack of dental coverage and shortages in dentists treating young children, particularly those who are uninsured or publicly insured.[12,13] Once children enter school, there are additional opportunities for screening and treatment.[14]

In 2004, the US Preventive Services Task Force (USPSTF) recommended that primary care clinicians prescribe dietary fluoride supplementation to children >6 months of age whose primary water source is deficient in fluoride (B recommendation).[15] The USPSTF found insufficient evidence to recommend for or against primary care clinician risk assessment of +children <5 years of age for the prevention of dental disease (I recommendation). The USPSTF found no validated risk-assessment tools or algorithms for assessing dental disease risk by primary care clinicians, and little evidence on the accuracy of primary care clinicians in performing oral examinations or assessing dental caries risk.[2] In addition, the USPSTF found little evidence on the effectiveness of parental education or referring children at high risk to dental care providers in reducing risk of caries and related dental disease.

AIMS OF THIS REVIEW

This report was commissioned by the USPSTF to update its 2004 recommendation on dental caries prevention in children <5 years of age.[15] With the input of members of the USPSTF, we developed an analytic framework (Fig 1) and key questions to guide our literature search and review:

1. How effective is oral screening (including risk assessment) by the primary care clinician in preventing dental caries in children <5 years of age?
2. How accurate is screening by the primary care clinician in identifying children <5 years of age who:
   a. have cavitated or noncavitated caries lesions?

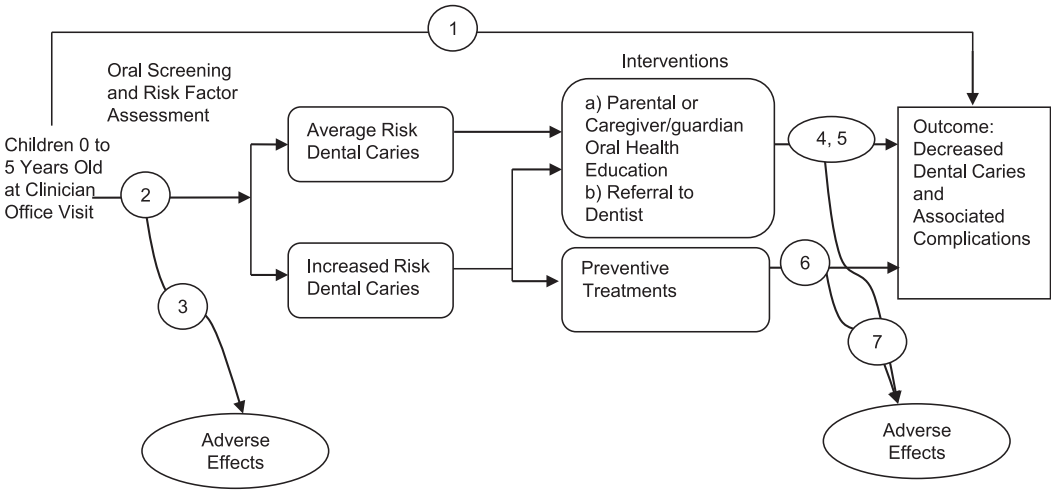

FIGURE 1
Analytic framework.

b. are at increased risk for future dental caries?

3. What are the harms of oral health screening by the primary care clinician?
4. How effective is parental or caregiver/guardian oral health education by the primary care clinician in preventing dental caries in children <5 years of age?
5. How effective is referral by a primary care clinician to a dentist in preventing dental caries in children <5 years of age?
6. How effective is preventive treatment (dietary fluoride supplementation, topical fluoride application, or xylitol) in preventing dental caries in children <5 years of age?
7. What are the harms of specific oral health interventions for prevention of dental caries in children <5 years of age (parental or caregiver/guardian oral health education, referral to a dentist, and preventive treatments)?

Key question 1 focuses on direct evidence on the effectiveness of oral screening (including oral examination and assessment of risk for future caries) by primary care clinicians in preventing future dental caries and associated complications, compared with not screening. Such direct evidence on the effectiveness of screening interventions is often limited. Therefore, the remainder of the analytic framework (key questions 2 through 7) evaluates the chain of indirect evidence needed to link screening with improvement in important health outcomes. Links in the chain of indirect evidence include the accuracy of screening to identify children with caries or at increased risk of developing caries, the effectiveness of interventions to reduce the incidence of dental caries and associated complications, and harms (including dental fluorosis) associated with screening and preventive treatments. Implicit in the indirect chain of evidence is that, to understand benefits and harms of screening, it is not sufficient to show that children at risk for dental caries can be identified; it is also necessary to show that there are effective treatments for those identified.

METHODS

This review was conducted at the Pacific Northwest Evidence-Based Practice Center under contract with the Agency for Healthcare Research and Quality (Contract No. HHSA-290-2007-10057-I, Task Order No. 13), by using the systematic review methods developed by the USPSTF.[16,17]

Search Strategies

We searched Ovid Medline (January 1999 to March 8, 2013) and the Cochrane Library Database (through the first quarter of 2013) for relevant articles, and reviewed reference lists for additional citations. Search strategies are shown in Supplemental Appendix 1.

Study Selection and Processes

Abstracts were selected for full-text review if they included children <5 years old (including those with caries at baseline), were relevant to a key question, and met the predefined inclusion criteria (Supplemental Appendix 2). We restricted inclusion to English-language articles and excluded studies published only as abstracts. Studies of nonhuman subjects were also excluded, and studies had to report original data.

We focused on studies of screening or diagnostic accuracy performed in primary care settings. For preventive treatments (key question 6), we also included studies of primary care–feasible treatments (treatments that could be administered or prescribed without requiring extensive dental training) performed in non–primary care settings. Treatment interventions were parental or caregiver education, referral to a dentist by a primary care clinician, and preventive treatments, including dietary fluoride supplementation, fluoride varnish, and xylitol. Interventions not commonly used or available in the United States (such as chlorhexidine varnish, povidone iodine rinses, and alternative methods for applying topical fluoride) are discussed in the full report,[18] as are studies that compared different doses of xylitol. Outcomes included decreased incidence of dental caries and associated complications and harms, including dental fluorosis. Many studies reported a composite caries outcome of the presence of 1 or more decayed (noncavitated or cavitated), missing (due to caries), or filled tooth surfaces in preschool-age children.[19] The abbreviation dmfs refers to decayed, missing, or filled primary tooth surfaces, and dmft refers to decayed, missing, or filled primary teeth (1 tooth may have more than 1 affected surface).

We included randomized controlled trials, nonrandomized controlled clinical trials, and cohort studies for all key questions. We also included an updated systematic review originally included in the 2004 USPSTF review of observational studies on risk of enamel fluorosis.[20,21] Community interventions for prevention of dental caries and school-based interventions for older children are addressed elsewhere by the US Community Services Task Force.[22]

At least 2 reviewers independently evaluated each study to determine inclusion eligibility. One investigator abstracted details about each article's study design, patient population, setting, screening method, treatment regimen, analysis, follow-up, and results.

A second investigator reviewed data abstraction for accuracy.

Quality Assessment and Synthesis

Two investigators independently applied criteria developed by the USPSTF[16,17] to rate the quality of each study as good, fair, or poor (Supplemental Appendix 3). Discrepancies were resolved through a consensus process. See Table 1 for a list of quality ratings for the included randomized trials. We assessed the aggregate internal validity (quality) of the body of evidence for each key question ("good," "fair," "poor") using methods developed by the USPSTF, based on the number, quality, and size of studies; consistency of results among studies; and directness of evidence.[16,17] Meta-analysis was not attempted because of methodological shortcomings in the studies and differences across studies in design, interventions, populations, and other factors.

RESULTS

Our literature search identified a total of 1215 citations, of which we reviewed 539 full-text publications and included 20 studies (Fig 2).

Benefits and Harms of Screening

No randomized trial or observational study compared clinical outcomes between children <5 years of age screened and not screened by primary care clinicians.

Accuracy of Oral Examination

One good-quality study found primary care pediatrician examination of Medicaid-eligible children <36 months of age (n = 258) after 2 hours of oral health education associated with a sensitivity of 0.76 (19/25) for identifying a child with 1 or more cavities and 0.63 (17/27) for identifying children in need of a dental referral, compared with a pediatric dentist evaluation (Supplemental Tables 5 and 6).[41] Specificity was 0.95 and 0.98, respectively. The need for referral was determined by the presence of a cavity, soft tissue pathology, or evidence of tooth or mouth trauma. A study included in the 2004 USPSTF review found pediatrician examination after 4 hours of oral health education associated with a sensitivity of 1.0 and specificity of 0.87 for identifying nursing caries in children 18 to 36 months of age.[42]

Accuracy of Risk Assessment for Future Dental Caries

Although risk assessment tools for use in primary care settings are available,[43,44] we found no study on the accuracy of risk assessment by primary care clinicians using these or other instruments.

Effectiveness of Oral Health Education

No trial specifically evaluated an educational or counseling intervention by a primary care clinician to prevent dental caries. Two nonrandomized trials (1 fair quality[27] and 1 poor quality[24,25]) found multifactorial interventions that included an educational component were associated with decreased caries outcomes in underserved children <5 years of age. Other components of the interventions included additional pediatrician training, electronic medical record reminders, and provision of tooth-brushing materials. In addition to use of a nonrandomized design, other methodological shortcomings in the poor-quality study were high attrition and failure to adjust for confounders.[24,25]

Effectiveness of Dental Referral

No study directly evaluated the effects of referral by a primary care clinician to a dentist on caries incidence. A fair-quality retrospective cohort study (n = 14 389) found that having a first dental preventive visit after 18 months of age in Medicaid children with existing dental disease was associated with increased risk of subsequent dental procedures compared with having a first visit before 18 months of age (incidence density ratio ranged from 1.1 to 1.4, depending on time of first dental visit, after adjusting for gender, race, number of well-child visits, and other factors), but was not designed to determine referral source.[45]

Effectiveness of Preventive Treatments

Dietary Fluoride Supplementation

We identified no trials published since the 2004 USPSTF review on effects of dietary fluoride supplementation in children <5 years of age. One randomized trial[46] and 4 nonrandomized trials[47–50] included in the 2004 USPSTF review found dietary fluoride supplementation in settings with water fluoridation levels below 0.6 ppm F associated with decreased caries incidence versus no fluoridation (percentage reduction in incidence ranged from 48% to 72% for primary teeth and 51% to 81% for primary tooth surfaces).[2] In the single randomized trial (n = 140, fluoridation <0.1 ppm F), percent reductions in incidence ranged from 52% to 72% for teeth and 51% to 81% for tooth surfaces, depending on whether fluoride was given as tablets or drops.[46] Two of the trials with extended follow-up also found dietary fluoride supplementation associated with decreased incidence of caries at 7 to 10 years of age (reductions ranged from 33% to 80%).[47,51]

Fluoride Varnish

Two good-quality[28,31] and 1 fair-quality[34] trials published since the 2004 USPSTF review evaluated fluoride varnish (2.26% F) applied every 6 months versus no fluoride varnish (Table 2). Sample sizes ranged from 280 to 1146

TABLE 1 Quality Ratings of Randomized Controlled Trials

Author, Year, Title	Randomization Adequate?	Allocation Concealment Adequate?	Groups Similar at Baseline?	Eligibility Criteria Specified?	Outcome Assessors Masked?	Care Provider Masked?	Patient Masked?	Reporting of Attrition, Crossovers, Adherence, and Contamination	Loss To Follow-up: Differential/ High	Intention-To-Treat Analysis	Postrandomization Exclusions	Outcomes Prespecified	Funding Source	External Validity	Quality Rating
Alamoudi et al 2012[23] Effects of xylitol on salivary mutans *Streptococcus*, plaque level, and caries activity in a group of Saudi mother-child pairs	Unclear	Yes	Unclear	Yes	Unclear	No	No	Yes	Yes (very high)	Yes	Yes	Yes	The Deanship of Scientific Research, King Abdulaziz University, Jeddah, Saudi Arabia (Project No. 429/011-9)	Fair	Poor
Davies et al 2007[24] Challenges associated with the evaluation of a dental health promotion program in a deprived urban area	Not randomized	Unclear	Yes	Yes	Unclear	Unclear	Unclear	No	Yes	No	No	Yes	National Health Service Research and Development Program for Primary Dental Care	Fair	Poor
Davies et al 2005[25] A staged intervention dental health promotion program to reduce early childhood caries															
Kovari et al 2003[26] Use of xylitol chewing gum in daycare centers: a follow-up study in Savonlinna, Finland	NR	NR	Unclear	Yes	Unclear	No	No	Yes	No	Yes	No	Yes	Not reported	Limited	Fair

TABLE 1 Continued

Author, Year, Title	Randomization Adequate?	Allocation Concealment Adequate?	Groups Similar at Baseline?	Eligibility Criteria Specified?	Outcome Assessors Masked?	Care Provider Masked?	Patient Masked?	Reporting of Attrition, Crossovers, Adherence, and Contamination	Loss To Follow-up: Differential/ High	Intention-To-Treat Analysis	Postrandomization Exclusions	Outcomes Prespecified	Funding Source	External Validity	Quality Rating
Kressin et al 2009[27] Pediatric clinicians can help reduce rates of early childhood caries: effects of a practice-based intervention	Not randomized	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes	NIH/NIDCR and VA	Fair	Fair
Lawrence et al 2008[28] A 2-y community-randomized controlled trial of fluoride varnish to prevent early childhood caries in Aboriginal children	Yes	Unclear	Yes	Yes	Yes	No	No	Yes	No/No	Yes	No	Yes	The Institute of Aboriginal Peoples' Health of the Canadian Institutes of Health Research (Grant # MOP-64215) and the Toronto Hospital for Sick Children Foundation (Grant # XG 03-067)	Limited: Aboriginal communities in rural Canada	Good
Oscarson et al 2006[29] Influence of a low xylitol-dose on mutans streptococci colonization and caries development in preschool children	NR	NR	Yes	Yes	Yes	No	No	Yes	No	Yes	No	Yes	Grants from Count of Vasterbotten, the Patient Revenue Fund for Dental Prophylaxis and the Swedish Dental Society	Fair	Fair

TABLE 1 Continued

Author, Year, Title	Randomization Adequate?	Allocation Concealment Adequate?	Groups Similar at Baseline?	Eligibility Criteria Specified?	Outcome Assessors Masked?	Care Provider Masked?	Patient Masked?	Reporting of Attrition, Crossovers, Adherence, and Contamination	Loss To Follow-up: Differential/ High	Intention-To-Treat Analysis	Postrandomization Exclusions	Outcomes Prespecified	Funding Source	External Validity	Quality Rating
Seki et al 2011[30] Effect of xylitol gum on the level of oral mutans streptococci of preschoolers: block-randomized trial	No	No	Unclear (dfs index)	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	The Uemura Fund, Nihon University School of Dentistry, a grant to promote multidisciplinary research projects from the Ministry of Education, Science, Sports, Culture and Technology, Japan	Fair	Poor
Slade et al 2011[31] Effect of health promotion and fluoride varnish on dental caries among Australian Aboriginal children: results from a community-randomized controlled trial	Yes	Yes	Yes; some difference in fluoridation status	Yes	No	No	No	Yes	No/No	Yes	No	Yes	Project grant #320858 from the Australian National Health and Medical Research Council	Limited: Aboriginal communities in rural Australia	Good
Weinstein et al 2001[32] Equivalence between massive versus standard fluoride varnish treatments in high caries children aged 3-5 y	Yes	Unclear	Unclear	Yes	Unclear	Unclear	Unclear	Yes	Yes/Yes	Yes	No	Yes	Grant No. R03 DE-012138 from NIDCR/NIH	Head Start program	Fair

TABLE 1 Continued

Author, Year, Title	Randomization Adequate?	Allocation Concealment Adequate?	Groups Similar at Baseline?	Eligibility Criteria Specified?	Outcome Assessors Masked?	Care Provider Masked?	Patient Masked?	Reporting of Attrition, Crossovers, Adherence, and Contamination	Loss To Follow-up: Differential/ High	Intention-To-Treat Analysis	Postrandomization Exclusions	Outcomes Prespecified	Funding Source	External Validity	Quality Rating
Weinstein et al 2009[33] Randomized equivalence trial of intensive and semiannual applications of fluoride varnish in the primary dentition	Yes	Unclear	No; mean dmfs were not balanced	Yes	Yes	Unclear	Unclear	Yes	No/No	Yes	No	Yes	Grants No. R01DE14403 and U54DE14254 from NIDCR, NIH	Head Start program	Fair
Weintraub et al 2006[34] Fluoride varnish efficacy in preventing early childhood caries	Yes	Yes	Yes; stated no imbalances apparent	Yes	Yes	No	Yes	Yes	Yes/No	Yes	No	Yes	USPHS Research Grants P60 DE13058 and U54 DE142501 from the NIDCR and the NCMHD, NIH, and by the UCSF Department of Preventive and Restorative Dental Sciences	Limited: "Underserviced" community in United States; all nonwhite	Fair
Zhan et al 2012[35] Effects of xylitol wipes on carcinogenic bacteria and caries in young children	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	No/Yes (23% in 1 group)	Yes	No	Yes	California Society of Pediatric Dentistry Foundation, a Graduate Scientific Research Award from American Academy of Pediatric Dentistry, and NIH/NIDCR grant U54 DE019285	Single Center	Fair

dfs, decayed filled surfaces; NCMHD, National Center on Minority Health and Health Disparities; NIDCR, National Institute of Dental and Craniofacial Research; NIH, National Institutes of Health; UCSF, University of California San Francisco; USPHS, United States Public Health Service; VA, Veterans Affairs; NR, not reported.

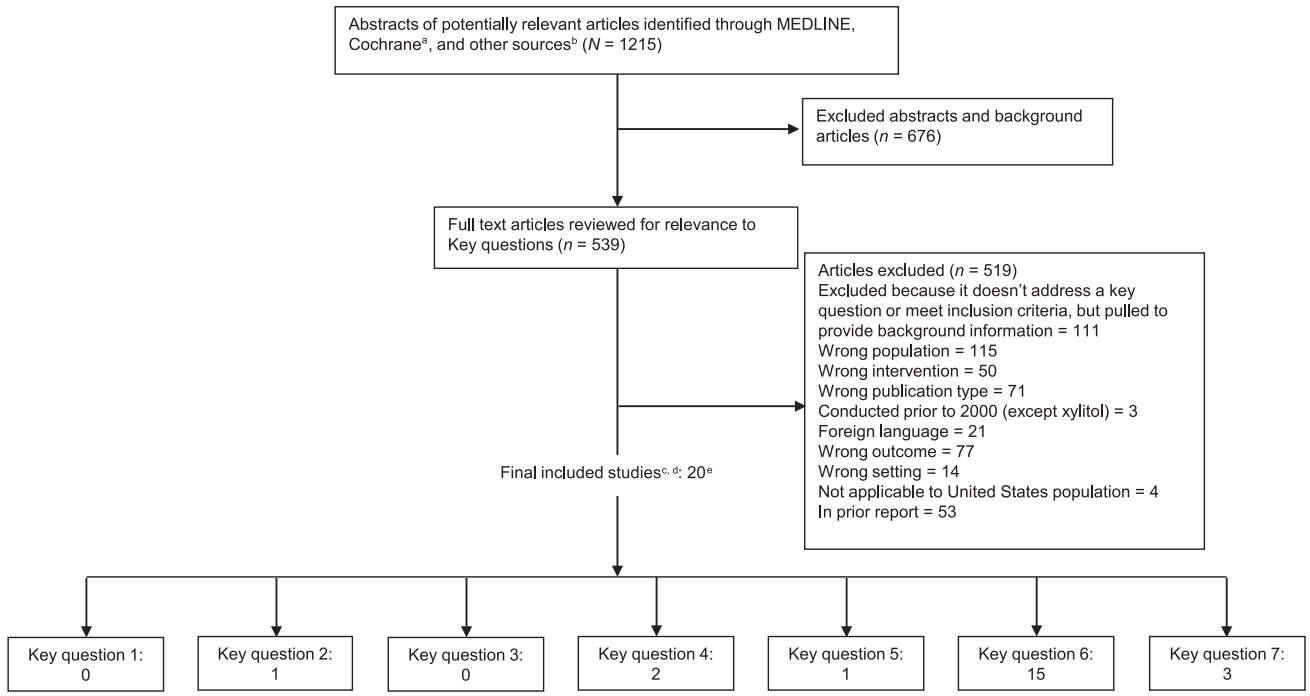

FIGURE 2

Literature flow diagram. [a]Cochrane databases include the Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews. [b]Identified from reference lists, hand searching, suggested by experts, and so forth. [c]Studies may have provided data for more than 1 key question. [d]Studies that provided data and contributed to the body of evidence were considered "included." [e]Five studies reported in the full evidence review[18] but not reported in this article evaluated topical fluoride varnishes not commonly used in the United States,[36,37] compared different dosing regimens of xylitol,[38] or evaluated povidone-iodine[39] or chlorhexidine varnish.[40]

children. The main methodological shortcoming in the fair-quality trial was differential loss to follow-up in the treatment groups.[34] The 2 good-quality trials were conducted in rural aboriginal populations in Canada (no fluoridation)[28] and Australia (<0.6 ppm F for >90% of children, baseline dmfs scores of 3.8 and 11.0)[31] and used a cluster design. The fair-quality trial enrolled underserved, primarily Hispanic and Chinese children in an urban United States setting with adequate fluoridation (1 ppm F) who were caries-free at baseline.[34] In all studies, the fluoride varnish was applied by dental personnel.

All 3 trials found use of fluoride varnish associated with decreased caries incidence after 2 years, although the difference was not statistically significant in the Canadian study.[28] Percent reductions in dmfs increment were 18% and 24% in the 2 good-quality trials,[28,31] and 59% in the fair-quality trial.[34] Absolute mean reductions in the number of affected surfaces ranged from 1.0 to 2.4. Results were consistent with findings from the 2004 USPSTF review, which reported a percent reduction in incident caries lesions that ranged from 37% to 63% (absolute reduction in the mean number of cavities per child of 0.67 to 1.24 per year), based on 6 trials, 2 of which were randomized.[52–57]

Two trials found multiple fluoride varnish applications within a 2-week period associated with no clear differences versus a standard application schedule of every 6 months,[32,33] and 1 trial found no clear difference between a once versus twice yearly schedule (Table 2).[34]

Xylitol

Three trials compared xylitol to no xylitol (Table 3).[29,30,35] Water was inadequately fluoridated in 1 trial[30] and water fluoridation status was not reported in the other 2. The trials varied with respect to dosing and formulation of xylitol. A fair-quality randomized trial (n = 115) of children 2 years of age found xylitol tablets (0.48 g) associated with reduced dmfs increment after 2 years, but the difference was not statistically significant (mean percent reduction 52%, absolute mean reduction in affected surfaces 0.42).[29] One small (n = 37) fair-quality randomized trial found xylitol wipes used 3 times per day for 1 year markedly more effective than placebo wipes in reducing caries among children aged 6 to 35 months (reduction in dmfs increment 91%, $P < .05$).[35] A poor-quality, nonrandomized trial found no effect of xylitol chewing gum (1.33 g) 4 times daily on incidence of caries in 4-year old children in Japan.[30] Xylitol was not an included intervention in the 2004 USPSTF review.

Two studies compared xylitol to topical fluoride (Table 3).[23,26] A cluster

TABLE 2 Summary of Topical Fluoride Preventive Treatments

Author, Year, Quality	Study Design	Interventions	Country; Setting; Fluoridation Status	Age at Enrollment	Sample Size	F-U, y	Mean Caries Increment	Absolute Reduction in Caries Increment	Reduction in Caries Increment	Other Dental Caries Outcomes
Lawrence et al 2008[28] Good	Cluster RCT (20 clusters)	A: 0.3–0.5 mL 5% sodium fluoride varnish applied to full primary dentition every 6 mo B: No fluoride varnish	Canada; Rural Aboriginal communities; Water fluoridation status: No fluoridation	2.5 y	1146	2	dmfs A: 11.0 (4.3)[a] B: 13.4 (6.1)[a] $P = .24$ ($P = .18$)[a]	2.4 (1.8)[a]	18% (29%)[a]	A versus B Dental caries in aboriginal cohort: 72% (595/832) vs 75% (247/328), adjusted OR 0.72 (95% CI 0.42–1.25); NNT 26 Dental caries in those caries-free at baseline: 44% (157/354) vs 58% (73/126); adjusted OR 0.63 (95% CI 0.33–1.1); NNT 7.4
Slade et al 2011[31] Good	Cluster RCT (30 clusters)	A: 0.25 mL of 5% sodium fluoride varnish to maxillary anterior teeth/molars, mandibular molars/incisors every 6 mo, education/advice to caregiver with toothbrush/paste provided, community oral health promotion program B: No interventions	Australia; Rural Aboriginal communities; Water fluoridation status: 81% to 92% had <0.6 ppm F	2.8 y	666	2	dmfs A: 7.3 B: 9.6[b] $P < .05$	2.3	24%	
Weinstein et al 2001[32] Fair	RCT with 3 treatment groups	A: One application of 5% fluoride varnish at baseline and 6 mo B: Three applications of 5% fluoride varnish within 2 wk of baseline C: Three applications of 5% fluoride varnish within 2 wk of baseline and 6 mo	United States; Head Start programs; Water fluoridation status: NR	3–5 y	111	1	Clinical dmfs A: 4.6 B: 3.2 C: 4.7 $P = .65$ Radiographic mean dmfs A: 0.9 B: 0.5 C: 0.1 $P = .28$	Not calculated	Not calculated	

TABLE 2 Continued

Author, Year, Quality	Study Design	Interventions	Country; Setting; Fluoridation Status	Age at Enrollment	Sample Size	F-U, y	Mean Caries Increment	Absolute Reduction in Caries Increment	Reduction in Caries Increment	Other Dental Caries Outcomes
Weinstein et al 2009[33] Fair	RCT with 2 treatment groups	A: One 5% fluoride varnish treatment and 2 placebo treatments every 6 mo	United States	55–56 mo	515	3	dmfs	2.4	24%	Adjusted rate ratio of new tooth decay in primary surfaces 1.13 (95% CI 0.94–1.37)
		B: One set of 3, 5% fluoride varnish treatments over 2 wk once per year and 3 placebo treatments over 2 wk, 6 mo later	Recruitment setting: Head Start programs				A: 7.4			
			Water fluoridation status: NR (Yakima voters approved fluoridation in 1999)				B: 9.8			
							$P = .001$			
Weintraub et al 2006[34,c] Fair	RCT	A: 0.1 mL of 5% sodium fluoride varnish per arch applied twice per year with 4 intended applications	United States; Family dental center and public health center serving primarily low-income, underserved Hispanic and Chinese populations	1.8 y	280	2	$d_{2+}fs$[d]	1.0	59% (A + B vs C)	A vs B vs C
		B: 0.1 mL of 5% sodium fluoride varnish per arch applied once per year with 2 intended applications	Water fluoridation status: Approximately 1 ppm				A: 0.7			Caries lesions at 12 mo: 13% (11/83) vs 15% (13/86) vs 29% (27/92); RR 0.45 (95% CI 0.24–0.85); NNT 7 for A vs C and 0.52 (95% CI 0.28–0.93); NNT 8 for B vs C
		C: No fluoride varnish					B: 0.7			Caries lesions at 24 mo: 4.3% (3/70) vs 14% (10/69) vs 24% (15/63); RR 0.18 (95% CI 0.06–0.59); NNT 6 for A vs C and 0.61 (95% CI 0.30–1.26); NNT 11 for B versus C
							C: 1.7			
							$P < .01$ for A or B vs C			

ANOVA, analysis of variance; CI, confidence interval; $d_{2+}fs$, number of decayed or filled surfaces; F-U, follow-up; NNT, number needed to treat; NR, not reported; RCT, randomized controlled trial; RR, relative risk.

[a] Children caries-free at baseline.

[b] Adjusted.

[c] In the fluoride varnish treatment group, some children received a placebo varnish instead of fluoride varnish due to protocol errors.

[d] Participants were caries-free at baseline.

TABLE 3 Summary of Xylitol Preventive Treatments

Author, Year, Quality	Study Design	Interventions	Country; Setting; Fluoridation Status	Age at Enrollment	Sample Size	F-U, y	Mean Caries Increment	Absolute Reduction in Caries Increment	Reduction in Caries Increment	Other Dental Caries Outcomes
Alamoudi et al 2012[23] Poor	RCT	A: Xylitol chewable tablets (1.2 g, 84% xylitol) chewed for 5 min 3 times daily B: Fluoride varnish, every 6 mo throughout study	Saudi Arabia; Recruitment setting: Well-infant clinics and dental clinics; Water fluoridation status: Not reported	2–5 y	34	1.5	dmft A: 0.8 B: 4.4 *P* = not reported	3.6	82%	A vs B dmft at baseline: 8.4 vs 10.3 (*P* = .19) dmft at 18 mo: 9.2 vs 14.7 (*P* = .001)
Kovari et al 2003[26, a] Fair	Cluster RCT (11 clusters)	A: 65% Xylitol gum 3 times per day, chewed for 3–5 min, for total of 2.5 g/d B: Tooth brushing with 0.05% NaF toothpaste after lunch	Finland; Recruitment setting: day care centers; Water fluoridation status: Not reported	3–6 y	786	3–6	Not reported	Not reported	Not reported	A vs B Caries at 7 y old: 31% (98/316) vs 35% (149/427), RR 0.88 (95% CI 0.72–1.10) Caries at 9 y old: 43% (133/310) vs 51% (221/434), RR 0.84 (95% CI 0.72–0.99) dmft: 1.1 vs 1.0 at 7 y, 1.2 vs 1.6 at 9 y
Oscarson et al 2006[29] Fair	RCT	A: One 0.48-g xylitol tablet at bedtime after brushing for 6 mo; then 1 tablet twice daily to age 3 y and 6 mo B: No tablets	Sweden; Recruitment setting: Public dental clinic; Water fluoridation status: Not reported	25 mo	115	2	dmfs A: 0.38 B: 0.80 *P* > .05	0.42	52%	A vs B Dental caries: 18% (10/55) vs 25% (16/63), OR 0.65 (95% CI 0.27–1.59)
Seki et al 2011[30] Poor	Cluster, non–randomized controlled clinical trial (3 clusters)	A: Xylitol chewing gum (100% xylitol, 1.33 g); 1 pellet chewed 5 min 4 times daily B: No intervention	Japan; Recruitment setting: Preschool; Water fluoridation status: Not reported (states fluoridation "limited" in Japan)	66%–72% 4 y old	161	1	dfs A: 3.3 B: 3.4 *P* > .05	0.1	3%	A vs B Development of caries from baseline–6 mo: 1.7 vs 1.6 (*P* > .05) Development of caries from 6 mo–1 y: 1.6 vs 1.8 (*P* > .05)

TABLE 3 Continued

Author, Year, Quality	Study Design	Interventions	Country; Setting; Fluoridation Status	Age at Enrollment	Sample Size	F-U, y	Mean Caries Increment	Absolute Reduction in Caries Increment	Reduction in Caries Increment	Other Dental Caries Outcomes
Zhan et al 2012[35] Fair	RCT	A: Xylitol wipes, 2 at a time, 3 times per day (estimated daily dosage 4.2 g) every 3 mo B: Placebo wipes	United States; Recruitment setting: University pediatric clinic; Water fluoridation status: Not reported	6–35 mo	37	1	dmfs[b] A: 0.05 B: 0.53 *P* = .01	0.48	91%	A vs B New caries lesions at 1 y[b]: 5% vs 40% (*P* = .03); NNT 3 ITT analysis of new caries lesions at 1 y: 5% vs 32%; RR 0.14 (95% CI 0.02–1.07); NNT 4

CI, confidence interval; dfs, decayed and filled surfaces; dmft, decayed, missing, and filled teeth; F-U, follow-up; NNT = number needed to treat; OR, odds ratio; RCT, randomized controlled trial; RR, relative risk.

[a] Baseline caries status not defined.

[b] Numbers based on per protocol analysis.

randomized trial found no difference between 65% xylitol gum 3 times per day versus tooth brushing with fluoride, but was conducted in a supervised day care setting, and enrolled children up to 6 years of age, potentially limiting its applicability to younger children.[26] A poor-quality trial found xylitol chewable tablets (1.2 g 3 times daily) more effective than fluoride varnish once every 6 months.[23]

Harms of Preventive Interventions

A systematic review included in the 2004 USPSTF review (searches conducted through September 1997) has subsequently been updated (searches conducted through June 2006).[21] The update included 5 new observational studies on the association between early childhood intake of fluoride supplements and risk of fluorosis.[58–62] Determinations of early childhood exposures were all based on retrospective parental recall, with fluorosis assessed at 8 to 14 years of age. Results of the new studies were consistent with the original systematic review, with intake of fluoride supplements before 7 years of age (primarily before 3 years of age) associated with increased risk of fluorosis. Risk estimates ranged from an odds ratio (OR) of 10.8 (95% confidence interval 1.9–62.0) with intake during the first 2 years of life,[61] to a slight increase in risk (OR 1.1–1.7, depending on comparison).[58] One study reported a dose-dependent association, with an OR of 1.8 (95% confidence interval 1.4–2.4) for each year of supplementation.[62] In the prior systematic review, the ORs for dental fluorosis associated with regular early childhood use ranged from 1.3 to 10.7 in 10 studies that relied on retrospective recall and relative risks ranged from 4.2 to 15.6 in 4 studies that recorded supplement use at the time of exposure. We identified no studies published since

the updated systematic review on the association between early childhood intake of dietary fluoride supplements and risk of enamel fluorosis.

No study reported the risk of fluorosis associated with use of fluoride varnish. However, the degree of systemic exposure after application of fluoride varnish is believed to be low.

Two trials reported diarrhea in 11% of children allocated to xylitol chewing gum[30] or syrup.[38] Other trials of xylitol[23,26,29] did not report rates of diarrhea.

DISCUSSION

As in the 2004 USPSTF review,[2] we found no direct evidence on the effects of screening for dental caries by primary care clinicians in children <5 years of age versus no screening on caries incidence and related outcomes. Evidence reviewed for this update is summarized in Table 4.

New evidence was consistent with findings from the 2004 USPSTF review in showing that fluoride varnish in children <5 years of age is effective at reducing caries incidence.[28,31,34] Because trials were primarily conducted in higher-risk children (based on community water fluoride levels or socioeconomic status), the applicability of these findings to children not at increased risk may be limited, particularly for studies conducted in countries and settings in which sources of fluoride and health behaviors differ markedly from the United States. In all trials, the varnish was applied by dental personnel, although fluoride varnish is considered easy to apply with minimal training.[63,64]

We identified no new trials on the effectiveness of dietary fluoride supplementation in children <5 years of age. Although the 2004 USPSTF review found dietary fluoride supplementation to be effective at reducing caries incidence in children <5 years of age primarily in settings with water fluoridation levels <0.6 ppm F, conclusions were mostly based on nonrandomized trials.[2] Newer observational studies were consistent with the 2004 USPSTF review in finding an association between early childhood intake of dietary fluoride supplementation and risk of enamel fluorosis.[21] Risk of enamel fluorosis appears to be affected by total intake of fluoride (from supplements, drinking water, other dietary sources, and dentifrices), as well as age at intake, with intake before 2 to 3 years of age appearing to confer highest risk.[65] Although the prevalence of enamel fluorosis has increased in the United States, severe fluorosis is uncommon, with a prevalence of <1%.[66–68]

Trials of xylitol in children <5 years of age found no clear effects on caries incidence, although studies differed in the doses and formulations evaluated.[29,30,35] The most promising results were from a small trial of xylitol wipes that reported a marked decrease in caries incidence, but require confirmation.[35]

Evidence remains limited on the accuracy of primary care clinicians in identifying caries lesions in children <5 years of age or predicting caries incidence. One study not included in the previous USPSTF review found that primary care pediatricians missed 37% of children in need of a dental referral and 24% of children with a cavity, compared with a pediatric dentist examination, although specificity was high.[41] No study evaluated the diagnostic accuracy of caries risk assessment instruments administered by primary care clinicians, despite the availability of instruments designed for use in primary care settings.[43] Some studies have assessed caries risk assessment instruments in children younger than 5 years of age, but the instruments were not administered by primary care providers or in primary care settings. These instruments often incorporate findings from an oral examination by dental personnel, and include tests not commonly obtained in primary care (such as mutans streptococci levels, saliva secretion level, or saliva buffer capacity),[69,70] likely limiting their applicability to primary care settings.[71,72]

No trial specifically evaluated the effectiveness of parental or caregiver education on caries outcomes, although limited evidence from 2 trials suggests that multifactorial interventions that included an educational component could be effective.[12,24,25,27] Although some evidence indicates that health care providers' recommendation for dental care increases the likelihood of subsequent dental visits in young children,[12] no trial directly evaluated the effectiveness of primary care referral to a dentist on caries outcomes, although 1 retrospective cohort study suggests that earlier dental care (before 18 months of age) is associated with fewer subsequent dental procedures in children with dental disease at baseline.[45]

Our review has some limitations. We excluded non–English language articles, which could result in language bias, although we did not identify non–English language studies otherwise meeting inclusion criteria. We did not search for studies published only as abstracts and could not formally assess for publication bias with graphical or statistical methods because of small numbers of studies for each key question and differences in study design, populations, and outcomes assessed. We found few or no randomized trials for a number of key questions. Therefore, we included nonrandomized trials, as well as observational

TABLE 4 Summary of Evidence

Main Findings From 2005 USPSTF Review	Number and Type of Studies Identified for Update Overall Quality[a]	Limitations	Consistency	Applicability	Summary of Findings
Key Question 1. How effective is oral screening (including risk assessment) by the primary care clinician in preventing dental caries in children <5 y of age?					
No evidence	No studies	No studies	No studies	No studies	No randomized trial or observational study compared clinical outcomes between children <5 y of age screened and not screened by primary care clinicians.
Key Question 2a. How accurate is screening by the primary care clinician in identifying children <5 y of age who have cavitated or noncavitated caries lesions?					
One study found pediatrician examination after 4 h of oral health education associated with a sensitivity of 1.0 and specificity of 0.87 for identifying nursing caries in children 18 to 36 mo of age.	One cohort study Overall quality: Fair	Evidence limited to two studies, one good-quality	N/A	Study conducted in a primary care setting	One study found primary care pediatrician examination after 2 h of oral health education associated with a sensitivity of 0.76 for identifying a child with 1 or more cavities and 0.63 for identifying children <36 mo of age in need of a dental referral, compared with a pediatric dentist evaluation.
Key Question 2b. How accurate is screening by the primary care clinician in identifying children <5 y of age who are at increased risk for future dental caries?					
No evidence	No studies	No studies	No studies	No studies	No study evaluated the accuracy of general assessment or use of risk assessment tools by primary care clinicians to identify children at increased risk for future dental caries.
Key Question 3. What are the harms of oral health screening by the primary care clinician?					
No evidence	No studies	No studies	No studies	No studies	No randomized trial or observational study compared harms between children <5 y of age screened and not screened by primary care clinicians.
Key Question 4. How effective is parental or caregiver/guardian oral health education by the primary care clinician in preventing dental caries in children <5 y of age?					
No evidence	1 randomized trial, 1 nonrandomized trial Overall quality: Poor	Nonrandomized design, high attrition, failure to adjust for confounders.	Moderate inconsistency	Education evaluated as part of a multifactorial intervention	No trial specifically evaluated an educational or counseling intervention to prevent dental caries. Two studies found multifactorial interventions that included an educational component associated with decreased incidence or prevalence of cavities in underserved children <5 y of age.

TABLE 4 Continued

Main Findings From 2005 USPSTF Review	Number and Type of Studies Identified for Update Overall Quality[a]	Limitations	Consistency	Applicability	Summary of Findings
Key Question 5. How effective is referral by a primary care clinician to a dentist in preventing dental caries in children <5 y of age?					
No evidence	1 cohort study Overall quality: Poor	Study not designed to determine whether a primary care referral was the source of the initial preventive visit	N/A	Medicaid population, higher-risk children	No study directly evaluated the effects of referral by a primary care clinician to a dentist on caries incidence. One study found a first dental preventive visit after 18 mo of age in children with existing dental disease associated with increased risk of subsequent dental procedures compared with a first visit before 18 mo of age, but was not designed to determine referral source.
Key Question 6. How effective is preventive treatment with dietary fluoride supplementation in preventing dental caries in children <5 y of age?					
Six trials of dietary fluoride supplements. One randomized trial and 4 other trials found oral fluoride supplementation in settings with water fluoridation levels < 0.6 ppm F associated with decreased caries incidence versus no fluoridation (ranges of 48%–72% for primary teeth and 51%–81% for primary tooth surface).	No studies Overall quality: Fair	Limitations in previously reviewed studies include use of nonrandomized design, not controlling for confounders, inadequate blinding and high or unreported attrition	N/A	No studies	We identified no new trials on the effects of dietary fluoride supplementation in children <5 y of age on dental caries incidence.
Key Question 6. How effective is preventive treatment with topical fluoride application (fluoride varnish) in preventing dental caries in children <5 y of age?					
Three randomized trials found fluoride varnish more effective than no fluoride varnish in reducing caries incidence (percent reduction 37%–63%, with an absolute reduction in the mean number of cavities per child of 0.67–1.24 per year.)	3 randomized trials[b]; Overall quality: Fair	High loss to follow-up, failure to describe adequate blinding, and failure to describe adequate allocation concealment	Consistent	Rural settings with inadequate fluoridation or low socioeconomic status settings	Three randomized trials published since the previous review found fluoride varnish more effective than no fluoride varnish in reducing caries incidence (percent reduction in caries increment 18%–59%). Other trials evaluated methods of topical fluoride application not used in the United States or compared different doses or frequencies of topical fluoride.

TABLE 4 Continued

Main Findings From 2005 USPSTF Review	Number and Type of Studies Identified for Update Overall Quality[a]	Limitations	Consistency	Applicability	Summary of Findings
Key Question 6. How effective is preventive treatment with xylitol in preventing dental caries in children <5 y of age?					
No studies (not included in the prior review)	4 randomized trials; 1 nonrandomized[b] Overall quality: Fair	Variability in xylitol formulation and dosing	Some inconsistency	Children from settings in which water was not fluoridated or fluoridation limited	Three trials reported no clear effects of xylitol versus no xylitol on caries incidence in children younger than 5 y, with the most promising results from a small ($n = 37$) trial of xylitol wipes. One trial found no difference between xylitol and toothbrushing.
Key Question 7. What are the harms of specific oral health interventions for prevention of dental caries in children <5 y of age (parental or caregiver/guardian oral health education, referral to a dentist, and preventive treatments)?					
One systematic review of 14 observational studies found dietary fluoride supplementation in early childhood associated with increased risk of fluorosis; ORs ranged from 1.3–15.6 and prevalence ranged from 10%–67%.	5 observational studies in an updated systematic review Overall quality: Fair	Use of retrospective parental recall to determine exposures	Consistent	Doses of fluoride generally higher than currently recommended	We identified no studies published since the updated systematic review on the association between early childhood ingestion of dietary fluoride supplements and risk of enamel fluorosis. Five new studies in an updated systemic review were consistent with previously reported findings in showing an association between early childhood ingestion of systemic fluoride and enamel fluorosis. Other than diarrhea reported in 2 trials of xylitol, harms were poorly reported in other trials of caries prevention interventions in children <5 y of age.

[a] Overall quality is based on new evidence identified for this update plus previously reviewed evidence.

[b] Five studies reported in the full evidence review[18] but not reported in this article evaluated topical fluoride varnishes not commonly used in the United States,[36,37] compared different dosing regimens of xylitol,[38] or evaluated povidone-iodine[39] or chlorhexidine varnish.[40] N/A, not applicable.

studies (for harms), which are more susceptible to bias and confounding than are well-conducted randomized trials.

Research is needed to identify effective oral health educational and counseling interventions for parents and caregivers of young children. Research is also needed to validate the accuracy and utility of caries risk assessment instruments for use in primary care settings, and to determine how referral by primary care physicians of young children for dental care affects caries outcomes.

CONCLUSIONS

Dental caries is common in young children, many of whom do not receive dental care. Dietary fluoride supplementation and fluoride varnish are primary care–feasible interventions that appear to be effective at preventing caries outcomes in higher-risk children. Dietary fluoride supplementation in early childhood is associated with risk of enamel fluorosis, which is usually mild. More research is needed to understand the accuracy of oral health examination and caries risk assessment by primary care providers, effectiveness of primary care referral for dental care, and effective parental and caregiver educational and counseling interventions.

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