Journal Pre-proof

Effectiveness of School Fluoride Delivery Programs: A Community Guide Systematic Review

Susan O Griffin PhD , Mei Lin MD , Christina R Scherrer PhD , Shillpa Naavaal MPH , David P Hopkins MD , Anita A Jones PhD , Tammy Alexander MEd , Virginia A Black RN , Elizabeth Clark RN , Lori K Cofano RDH , Raul I Garcia DMD , Anna Goddard PhD , Jane Grover DDS , Susan M Kansagra MD , Thomas E Kottke MD , Elizabeth C Lense DDS , Tooka Zokaie MPH , the Community Preventive Services Task Force

PII: S0749-3797(25)00114-X
DOI: https://doi.org/10.1016/j.amepre.2025.04.003
Reference: AMEPRE 7633

To appear in: *American Journal of Preventive Medicine*

Please cite this article as: Susan O Griffin PhD , Mei Lin MD , Christina R Scherrer PhD , Shillpa Naavaal MPH , David P Hopkins MD , Anita A Jones PhD , Tammy Alexander MEd , Virginia A Black RN , Elizabeth Clark RN , Lori K Cofano RDH , Raul I Garcia DMD , Anna Goddard PhD , Jane Grover DDS , Susan M Kansagra MD , Thomas E Kottke MD , Elizabeth C Lense DDS , Tooka Zokaie MPH , the Community Preventive Services Task Force, Effectiveness of School Fluoride Delivery Programs: A Community Guide Systematic Review, *American Journal of Preventive Medicine* (2025), doi: https://doi.org/10.1016/j.amepre.2025.04.003

This is a PDF file of an article that has undergone enhancements after acceptance, such as the addition of a cover page and metadata, and formatting for readability, but it is not yet the definitive version of record. This version will undergo additional copyediting, typesetting and review before it is published in its final form, but we are providing this version to give early visibility of the article. Please note that, during the production process, errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

© 2025 Published by Elsevier Inc.

Journal Pre-proof

Effectiveness of School Fluoride Delivery Programs: A Community Guide Systematic Review

Susan O Griffin, PhD,[1*] Mei Lin, MD,[1] Christina R Scherrer, PhD,[2] Shillpa Naavaal, MPH,[3] David P Hopkins, MD,[4] Anita A Jones, PhD,[5] Tammy Alexander, MEd,[6] Virginia A Black, RN,[7] Elizabeth Clark, RN,[7] Lori K Cofano, RDH,[8] Raul I Garcia, DMD,[9] Anna Goddard, PhD,[10] Jane Grover, DDS,[11] Susan M Kansagra, MD,[12] Thomas E Kottke, MD,[13] Elizabeth C Lense, DDS,[11] Tooka Zokaie, MPH[14], the Community Preventive Services Task Force

[1]Division of Oral Health, Centers for Disease Control and Prevention, Atlanta GA, sig1@cdc.gov, [2]Department of Systems and Industrial Engineering, Kennesaw State University, Kennesaw GA [3]Pediatric Dentistry and Dental Public Health, Virginia Commonwealth University, Richmond VA,[4]Community Guide Program, Office of Science, CDC, Atlanta GA, [5]National Institute for Occupational Safety and Health, CDC, Atlanta GA, [6]School-Based Health Alliance, Washington DC, [7]National Association of School Nurses, Silver Spring MD, [8]Association of State and Territorial Dental Directors, Reno NV, [9]Department of Health Policy & Health Services Research, Boston University Henry M. Goldman School of Dental Medicine, Boston MA, [10] Child & Family Agency, New London CT, [11]American Dental Association, Chicago IL, [12]North Carolina Division of Public Health, Raleigh NC, [13]Health Partners Institute, Minneapolis MN, [14]School of Public Health, University of Illinois Chicago, Chicago IL

Word Count: 3964

Figure Count: 4

Table Count: 0

Journal Pre-proof

ABSTRACT

Introduction: Although preventable, dental caries remains highly prevalent. Many children do not receive preventive dental services routinely in clinical settings. This review examined the effectiveness of school (preschool through high school) fluoride varnish delivery programs (SFVDP) in preventing caries.

Methods: Community Guide systematic review methods were followed. In 2024, databases were searched for studies published through December 2023 on SFVDP effectiveness in increasing fluoride

varnish (FV) receipt and decreasing caries. Included studies had to be written in English, published in peer-reviewed journals, and conducted in upper-middle or high-income countries. Data synthesis conducted in 2024 used median RR and interquartile interval (IQI) to summarize findings across studies.

Results: Of 31 included studies with 60,780 students, 25 were randomized controlled trials—20 with good quality of execution. Most studies were conducted in low socioeconomic status (SES) areas among students at elevated caries risk. SFVDP reduced caries initiation by 32% (IQI: 21%, 37%) in permanent teeth (19 studies, 25,826 students) and by 25% (IQI: 4%, 37%) in primary teeth (12 studies, 4,304 students). Stratified assessments indicated findings were largely applicable to different settings, populations, and intervention characteristics. Two studies found SFVDP significantly increased the number of annual FV applications and two found that SFVDP effectiveness was inversely related to SES.

Discussion: About 30% of states report having no SFVDPs. Possible barriers to implementation include that Medicaid in some states only reimburses dental and medical professionals and does not reimburse non-dental providers for FV delivered to children older than 6 years.

Journal Pre-proof

INTRODUCTION

Untreated tooth decay can diminish a child's ability to eat, speak, learn, and play.[1] Prevalences of lifetime and untreated tooth decay in the US are, respectively, 23.3% and 10.4% in the primary dentition of children aged 2 to 5 years and 56.8% and 16.6% among adolescents aged 12 to 19 years.[2] Untreated tooth decay is significantly higher for non-Hispanic Black (20.4%) and Mexican American (20.8%) adolescents than for non-Hispanic White (15.6%) adolescents.[2] Reducing the prevalence of lifetime and active tooth decay in youth are national health objectives.[3]

Fluoride varnish (FV) treatments to prevent tooth decay (dental caries) are provided off-label in the US.[4] There is strong evidence that FV prevents caries—about 37% of caries in the primary and 47% in the permanent dentition.[5] Delivery of FV in dental offices is recommended for children at elevated caries risk by the American Dental Association[6] and is a CMS quality measure.[7] The United States Preventive Services Task Force (USPSTF), which makes recommendations for preventive services delivered in primary care settings, also recommends FV treatments for children from the time the first tooth erupts to age 5 years[8] but found insufficient evidence for youth aged 5 to 17 years.[9] Receipt of topical fluoride, which includes FV, during annual dental visits is low—less than 18% of children from families with lower incomes received a treatment in 2013–2014.[10] There are also significant disparities in receipt by race and ethnicity.[10]

Schools can be an important setting for delivery of FV. In 2022, about 70% of state oral health programs reported having at least 1 school FV delivery program (SFVDP).[11] These programs apply FV (5% sodium fluoride) to the teeth of children attending preschools and schools either onsite (school-based) or at offsite venues (school-linked).[12] Schools with high percentages of free/reduced meal program participation are typically prioritized. FV can be applied by dental and medical professionals and trained lay workers. Other services may include caries risk assessment, oral hygiene instruction and supplies, oral health education, and referrals for dental care.

To date, there have been no systematic reviews on the effectiveness of SFVDPs in preschool through high school. This systematic review conducted for the Community Preventive Services Task Force (analytic framework available at Oral Health: School Fluoride Varnish Delivery Programs | The Community Guide) addresses the following questions:

Journal Pre-proof

How effective are SFVDPs:

a. In increasing the receipt of FV applications?

b. In preventing initiation of caries?

c. In preventing progression of caries?

d. In improving health equity?

- Reducing disparities in FV receipt?
- Reducing disparities in caries?

2. Does intervention effectiveness vary by characteristics of study communities, schools, participants, and intervention components?

3. Are there additional benefits or harms associated with SFVDPs?

METHODS

Community Guide systematic review methods were used.[13-15] Centers for Disease Control and Prevention librarians developed the search strategy (available at: Oral Health: School Fluoride Varnish Delivery Programs | The Community Guide) for the following databases: Medline (OVID); Embase (OVID); Global Health (OVID); Cochrane Oral Health Trial Registry; Cochrane Central; Scopus; ERIC (ProQuest); and CINAHL (EBSCO). The team searched for studies published from the database inception through December 31, 2023. The strategy searched for all studies with MeSH terms for FV and children. IRB approval was not required for this study.

Studies were included addressing any of the review questions if participants were recruited and/or provided FV in a school (preschool through high school) located in a World Bank designated high- or

Journal Pre-proof

upper-middle income country.[16] Guide methods typically restrict inclusion to high-income countries but due to the presence of some RCTs evaluating SFVDP in upper-middle income countries that were included in other reviews,[5, 8] this criteria was relaxed but findings were presented separately for the 2 income categories.

Studies were excluded if consisting solely of youth with medical or oral conditions that would likely preclude them from participation in a school program; having less than 9-month follow-up period; not published in English; not having a comparison; or not delivering varnish with 5% sodium fluoride. For studies evaluating effectiveness in preventing caries, the comparison group could be negative controls receiving usual care with no additional interventions or with other preventive interventions such as oral health education that were also provided to the intervention arm.

Teams of two reviewers independently screened search results and abstracted qualifying studies (Summary Evidence Table - Oral Health: School Fluoride Varnish Delivery Programs). Differences were reconciled first by the 2 abstractors, with unresolved differences brought to full review team. Reviewers considered the following when evaluating quality of study execution: description of the intervention, population, and sampling frame; assessment of intervention exposure and outcome reliability; description and use of appropriate analytic methods; attrition (i.e., whether >20% of the study population was lost to follow-up); and ability to control for confounding or biasing factors. Reviewers described studies as having good (0−1 limitations), fair (2−4), or limited (>4) quality of execution. Studies with limited quality of execution were excluded from the analyses.

Two caries outcomes were examined—initiation and progression (decay in enamel progressing to dentin) or regression (remineralization or arrestment of decay). Studies varied by how they defined caries initiation. When possible, caries measures that included non-cavitated (incipient) decay were

Journal Pre-proof

used. Caries measures included both number of affected teeth/surfaces per child (continuous) and presence of caries (dichotomous) measured at the tooth or child level. FV receipt outcomes included whether student received FV and number of annual applications per student.

Community Guide reviews include a wide variety of study designs (e.g., experimental studies with allocated control groups, observational studies with concurrent or historical control groups) and frequently summarize review findings using descriptive statistics such as the median and range or interquartile range of effect sizes.[13] Because of the heterogeneity in caries measures, type of teeth included in measure, and different study designs, effectiveness was estimated using the relative risk ratio (RR equals change in intervention group relative to change in comparison group) for studies with a concurrent control group. Effectiveness was summarized across studies using the median RR, the mid-point of the series of estimates, and interquartile interval (IQI). In synthesizing evidence, only 1 effect measure was used per study. The following ranking criteria were used in selecting the reported measure from a study: 1) longest follow-up period; 2) highest application frequency; 3) caries measured at surface over tooth level; and 4) increment (change in mean caries) over incidence (change in prevalence). The team adhered to the convention of synthesizing caries prevention evidence separately for primary and permanent teeth.[5] Stratified analyses were performed for both types of dentition to examine applicability of findings to different categories of setting, population, intervention, and study design characteristics (applicable if upper value of IQI<1.00; likely applicable if median RR<1.00 and IQI including 1.00; evidence gap if no studies or one study with RR≥1.00 and not applicable if 2 or more studies and median RR≥1). Findings summarized for both dentitions were deemed not applicable if there was a finding of non-applicable for at least 1 category of dentition; evidence gap if not found inapplicable and at least one evidence gap, and applicable/likely applicable, otherwise.

Journal Pre-proof

RESULTS

Search Yield: The search yielded 1,040 citations (Figure 1). Review of titles, abstracts, and key words identified 797 articles as not meeting inclusion criteria. Review of the text of the remaining 243 articles indicated that an additional 139 did not meet inclusion criteria. Among the 104 articles (87 unique studies) abstracted, 61 were excluded for the following reasons: setting not school or indeterminate (9); split-mouth study (2); control group received treatment that FV group did not (26); varnish F content ≠ 5% (4); follow up < 9 months (1); insufficient data to estimate effect (8); FV group received treatment in addition to FV (6); protocol or review (4); and low quality of execution (1). Appendix Table 1 lists reason for exclusion per study. The body of evidence consisted of 43 articles (Appendix Table 2) representing 31 unique studies from which data were extracted. These unique studies represented 60,780 students.[17-47]

Study Characteristics: Among the 31 studies in the final body of evidence, 25 were RCTs—18 randomized at person level[17-20, 24, 25, 28, 32, 34, 35, 37-39, 41-44, 46] and 7 at school level.[22, 23, 27, 30, 31, 36, 45] (Appendix Table 3). Twenty RCTs were deemed as good quality of execution[18, 19, 22-25, 27, 31, 32, 34-36, 38, 39, 41-46] and 5 of fair quality.[17, 20, 28, 30, 37] Three studies were of controlled before-after design,[29, 40, 47] all deemed as fair quality of execution. Two studies were retrospective studies—one of good[33] and one of fair[21] quality of execution. One study[26] without a concurrent control group was deemed of fair quality of execution. Specific limitations in execution for each study are provided in Appendix Table 4. The most common limitations in study execution were inadequate description of the study population or intervention (9 studies) or sampling frame (7) and attrition exceeding 20% (8).

Five studies were conducted in North America (3 in the US,[19, 22, 26] 1 in Canada,[25] and 1 in the Dominican Republic[17]), 5 in South America,[18, 28, 39, 42, 47] 14 in Europe,[20, 21, 23, 29-31, 33, 35-38, 40, 44, 47] 6 in

Journal Pre-proof

Asia,[24, 32, 34, 41, 45, 46] and 1 in Africa.[27] About 2/3 of studies were from high-income countries[19-23, 25, 26, 29-33, 35-40, 44, 47] with the remaining studies from upper-middle income countries.[17, 18, 24, 27, 28, 34, 41-43, 45, 46] Among the 23 reporting studies, 18 were conducted exclusively in low social-economic status areas (SES, i.e., low-income or socially deprived communities)[17-19, 22, 23, 26-28, 30, 31, 33, 35, 36, 39, 40, 45-47] and 2 in both low-and high SES areas.[37, 43] Most studies solely served students at elevated caries risk[17-19, 22-31, 35, 36, 39-41, 44-47] and who lived in areas without optimally fluoridated water.[17, 18, 21, 23-25, 27, 30, 32-41, 44, 45, 47]

All studies delivered FV at least twice annually with 8 applying FV more than twice.[17, 22, 24, 27, 36, 38, 42, 44, 47] Dental providers applied FV in over 90% of studies.[17-21, 23-26, 28-34, 36-47] No studies included other fluoride modalities or sealants in both the control and treatment arms. Most studies (23) had durations of 20 to 48 months.[20-25, 27, 29-31, 33-40, 43, 45-47] The median number of participants completing the study across studies was 253 (IQI:183, 609). In most (22) studies the tooth surfaces examined for caries included chewing surfaces—8 of 10 examining caries in primary teeth[19, 29, 32, 33, 35, 39, 40, 44] and 10 of 16 examining caries in permanent teeth,[17, 18, 23, 28, 34, 36, 43, 45-47] and all 4 studies examining caries in both primary and permanent teeth.[22, 25, 27, 30] Further details on study characteristics are available at: Summary Evidence Table - Oral Health: School Fluoride Varnish Delivery Program) and Appendix Table 5.

Effectiveness in Increasing FV Receipt: Two studies examined whether SFVDPs increased receipt of FV. A Scottish study[35] compared receipt of 3 or more FV applications over 2 years among more than 1000 preschoolers randomly assigned to a FV treatment or control group. Receipt was 14 times higher among children assigned to the SFVDP (84%) relative to children not assigned (6%). A retrospective cohort study[21] of almost 25,000 Swedish adolescents compared FV receipt among students attending schools with and without a SFVDP. The mean number of annual FV applications was 3 times higher among students in schools with a SFVDP (2 applications) compared to students in schools without a SFVDP (0.6 applications).

Journal Pre-proof

Journal Pre-proof

SFVDP Participation: Participation rates in the 14 studies reporting the number of students in the target population[19, 20, 22, 23, 25, 26, 28, 30, 31, 33, 35, 36, 41, 47] appeared to be meaningful—median participation rate was 68% (IQI: 46%, 83%). Twelve of these studies were conducted in high-income countries[19, 20, 22, 23, 25, 26, 30, 31, 33, 35, 36, 47] including the 3 US studies[19, 22, 26] in which participation ranged from 60% to 83%. These rates are notably higher than the annual rate of receipt for at least one topical fluoride treatment in a dental office among low-income US youth—<18% in 2013–2014.[10]

Effectiveness in Preventing Caries Initiation: Nineteen studies[17, 18, 20-23, 25, 27, 30, 31, 34, 36-38, 42, 43, 45-47] with over 25,000 participants examined the effectiveness of SFVDPs in preventing caries initiation in permanent teeth (Figure 2). The RR was less than 1 in 17 studies. The median RR was 0.68 (IQI: 0.63, 0.79) or equivalently, the median reduction in caries initiation in permanent teeth from SFVDPs was 32% (IQI: 21%, 37%). The evidence for SFVDP effectiveness was applicable for all categories of characteristics for country income and urbanicity and for elementary and middle/high schools. No studies were identified in this review that examined the effectiveness of school-linked programs (Appendix Figure 1). Similarly, the evidence was applicable to all categories of population characteristics (SES status; water fluoridation status, and caries risk; Appendix Figure 2), intervention characteristics (provider and number of annual applications; Appendix Figure 3), and study characteristics (duration, size, and whether sealed chewing surfaces; Appendix Figure 4).

Twelve studies[19, 22, 25, 27, 29, 30, 32, 35, 39-41, 44] with nearly 3900 participants examined effectiveness in preventing caries initiation in the primary teeth (Figure 3). All but 2 of the studies were from high-income countries,[19, 22, 25, 29, 30, 32, 35, 39, 40, 44] including 2 US studies.[19, 22] Nine studies had RRs less than 1, including 1 US study.[19] The median RR was 0.75 (IQI: 0.63, 0.96) or equivalently the median reduction

in caries initiation in primary teeth from SFVDPs was 25% (IQI: 4%, 37%). The evidence for effectiveness of SFVDPs was applicable or likely applicable to all categories of setting characteristics (Appendix Figure 5), intervention characteristics (Appendix Figure 6), and study characteristics (Appendix Figure 7). Similarly, evidence was applicable or likely applicable to most population characteristics except for programs not serving children at elevated caries risk and those serving higher SES areas (Appendix Figure 8). Only 1 study was identified for the latter 2 categories and RR was greater than 1.

Applicability of Findings: Combining stratified analyses for permanent and primary teeth indicated that findings were applicable or likely applicable to different settings, populations, intervention characteristics, and study characteristics (Appendix Figure 10). Evidence was lacking for the effectiveness of programs that were school-linked or that served students living in higher SES communities or who had lower caries risk.

Effectiveness in Preventing Caries Progression: Eight studies[19, 20, 24, 26, 28, 37, 38, 41] were located examining caries progression or regression when FV was applied to existing caries. One before-after study that did not include a concurrent control group[26] was not included in the summary effect measure. Six studies with nearly 1500 participants examined progression of early-stage caries to more severe stages[19, 20, 28, 37, 38, 41]—4 in permanent teeth[20, 28, 37, 38] and 2 in the primary teeth.[19, 41] (Figure 4) Four studies were conducted in high-income countries[19, 20, 37, 38] including one US study.[19] Findings favored SFVDPs in 5 studies.[19, 28, 37, 38, 41] The median RR was 0.90 IQI (0.73, 0.93) or equivalently, the median reduction in early-stage caries progression in the SFVDP group was 10% (IQI:0.07, 0.27).

Journal Pre-proof

Four studies[19, 24, 28, 38] —two conducted in high-income countries[19, 38] including one US study[19] —with 486 participants examined SFVDP effectiveness in promoting remineralization/arrestment of caries (Appendix Figure 9) . Three studies favored SFVDPs[19, 24, 28] including one US study[19] being statistically significant. The median RR was 1.18 (IQR:1.1, 1.45) indicating that the median increase in arrestment of caries from SFVDPs was 18%. The before-after study without a concurrent control group conducted in the US (n=623)[26] found that among children receiving FV in school, the mean number of early-stage caries lesions decreased by 0.4 lesions per child (1.7 lesions before program to 1.3 lesions after program; $p<0.01$).

Potential Harms: Seventeen studies in this review examined adverse effects[18, 20, 22, 24, 25, 27, 32, 34-37, 39, 42-46] —15 noted none; [18, 20, 22, 24, 25, 27, 32, 34, 35, 37, 39, 42, 43, 45, 46] one noted a minor complaint over the color of teeth directly after applying FV[44] and one noted other minor complaints (mostly nausea) affecting less than 1% of participants.[36]

Potential Benefits: This review did not identify studies evaluating or describing additional benefits of SFVDPs.

Effectiveness in Improving Health Equity: The review did not identify studies examining the effect of SFVDPs on disparities in FV receipt. It should be noted, however, that 18 of 23 reporting studies were conducted in low-income or socially deprived areas.[17-19, 22, 23, 26-28, 30, 31, 33, 35, 36, 39, 40, 45-47] Two studies[33, 37] conducted in high-income countries examined whether programs reduced disparities in caries initiation. A study of 371 Swedish adolescents[37] compared the effectiveness of SFVDP in preventing caries initiation in approximal tooth surfaces over 3 years in areas of high and low social deprivation (defined by income and housing status). SFVDPs reduced caries initiation over 3 years by 69% and 66%

Journal Pre-proof

in low and moderate SES areas compared to 20% in high SES areas. Another study of 31,581 preschoolers in Scotland[33] used several socioeconomic domains (income, employment, education, health, access to services, crime, and housing) to define social deprivation. Multivariable regression models indicated that effectiveness of SFVDP was significantly higher in more deprived relative to less deprived areas.

DISCUSSION

This systematic review consisted of studies primarily conducted in low SES communities located in high or upper-middle income countries among children at elevated caries risk. Review findings on the effectiveness of SFVDPs in preventing caries initiation and regression; in achieving meaningful rates of participation; in increasing the number of FV treatments received; and in reducing disparities in the onset of tooth decay by income and other social determinants of health served as the basis for the CPSTF recommendation to deliver FV in schools based on strong evidence of effectiveness in preventing dental caries. (The Community Guide available at:: Oral Health: School Fluoride Varnish Delivery Programs | The Community Guide)

This review found SFVDPs to be effective across a wide range of setting, population, and intervention characteristics. Most of the effectiveness data, however, were for students at elevated caries risk living in low socioeconomic areas, indicating applicability of findings to US programs that prioritize these populations. There was no evidence to suggest that FV effectiveness varied by type of provider. Fluoride varnish was effective in preventing caries in both the chewing and non-chewing surfaces of teeth, suggesting that school programs could deliver FV as a stand-alone or adjunct service to dental sealants that primarily protect against decay occurring in the chewing surfaces.

Journal Pre-proof

SFVDPs typically screen children for untreated caries and refer children for needed care.[48] The review team postulated as potential benefits that participation in these programs could increase the number of children with an ongoing relationship with a dentist or dental home, ultimately resulting in reduced unmet treatment needs and improved quality of life. No studies in this review, however, evaluated these outcomes. The review team also postulated that SFVDPs could contribute to improved school performance. Although this review did not locate direct evidence related to school performance, the broader literature indicates that reducing untreated caries improves academic performance and reduces absenteeism.[49-51]

Similar to the USPSTF review, only minor complaints were found associated with SFVDP participation. Among included studies, none examined systemic exposure to fluoride from SFVDP participation. The USPSTF noted that systemic exposure to fluoride from FV is likely lower than exposure from other topical fluoride modalities.[8] One study[52] included in that review found that among school-aged children, prevalence of dental fluorosis (condition of enamel resulting from systemic exposure to fluoride while teeth are developing) did not statistically differ between children receiving FV during tooth development (27%) and similar children never receiving FV (35%).

Many state Medicaid programs reimburse for FV and sealants delivered in schools, but low Medicaid reimbursement[53] and care that is not reimbursed[26] can hinder program implementation and sustainability. Medicaid reimbursement policy regarding who can bill for preventive dental services and who can deliver them may pose greater barriers for non-dental providers. In most states, Medicaid only allows medical providers who are physicians or nurses with advanced degrees, i.e., nurse practitioners, to bill for FV application and typically does not reimburse for FV delivered to children older than age 6 years.[54] Although most states allow medical providers to delegate delivery to other types of health

Journal Pre-proof

professionals (e.g., medical assistants, registered nurses), in a few states other types of non-dental providers are not allowed to apply FV, even without seeking reimbursement.[54]

Although one advantage of FV is that it can be applied easily and with minimal training,[8] this review and the team's subsequent search of the broader literature suggests FV delivery programs employing trained lay workers are rare in the US. One qualitative analysis found that policies allowing school sealant programs to substitute less costly labor (e.g., dental hygienists) for more costly labor (e.g., dentists) contributed to successful implementation and expansion of these programs.[53] This suggests that removing barriers for less costly, trained lay workers to deliver FV could contribute to SFVDP sustainability. One entity that does use trained lay workers to provide FV is the Indian Health Services (IHS).[55] Very young children served by IHS have one of the highest rates of early childhood caries in the world.[56] Lay providers that have been used in IHS models include trained lay health workers[22] and Head Start staff including directors, health coordinators, and teachers.[56]

When implementing SFVDPs, optimal effectiveness will likely be achieved by applying FV at least twice annually and by introducing FV as soon as the first tooth erupts[22] —preschool (e.g., Early Head Start) for primary teeth beginning eruption at age 6 months and kindergarten for permanent teeth beginning eruption at age 6 years. In this review, all SFVDPs delivered FV at least twice annually and one study finding no evidence of effectiveness for SFVDPs serving children aged 3 to 5 years at extremely high caries risk noted that one possible explanation was implementing the program about 3 years after the first primary tooth erupts (around 6 months). Another study conducted in the same population but introducing FV sooner (at age 9 months) during physician visits found FV to be effective in preventing caries.[57]

Journal Pre-proof

The review team identified some gaps in the evidence base. Priority questions for future research included:

- How effective are SFVDPs in reducing disparities in the US for historically disadvantaged racial and ethnic groups and for rural areas?
- How can SFVDPs maximize school engagement and student participation?
- What can SFVDPs do to minimize delivery time and costs?

Limitations

Although the body of evidence was largely comprised of well-designed and well-executed studies, nine of the 31 included studies had an inadequate description of the intervention or study population and eight had loss to follow-up exceeding 20%. Publication bias cannot be ruled out, and it is possible that studies with null results were missing from the data set. In addition, there was high heterogeneity due to the variety in study design and caries outcomes. As a result, the team did not conduct a meta-analysis but instead provided descriptive statistics. When interpreting these findings readers should note that each study was weighted equally regardless of study design or sample size. Finally, the team did not statistically test for the applicability of findings to different settings and populations.

CONCLUSION

This review found SFVDPs to be effective in preventing caries initiation and progression. SFVDP also increased the number of FV treatments received and reduced disparities in caries initiation by income and other social determinants of health. Findings further suggest that SFVDPs prevent caries among school children of all ages, can be implemented in either rural or urban areas and in communities with and without fluoridated tap water, and can be delivered by dental and non-dental providers.

Journal Pre-proof

ACKNOWLEDGEMENTS

This study was supported by the Centers for Disease Control and Prevention (CDC). The work of CRS was funded through contract 21IPA2110130 and SN through contract 21IPA2110129. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the CDC. CRS and SN were also supported by the National Institutes of Health (NIH) under award number R15DE031428. NIH had no role in study design, data collection, analysis, interpretation, writing, or decision to submit for publication. The authors have no conflicts of interest to disclose. Names and affiliations of Community Preventive Services Task Force members can be found at https://www.thecommunityguide.org/task-force/communitypreventive-services-task-force-members.

Financial disclosure: No financial disclosures were reported by the authors of this paper.

Disclosure of which tasks each author completed: Susan O Griffin, Mei Lin, Christina R Scherrer, Shillpa Naavaal, Anita A Jones, and David Hopkins were involved in all aspects of this review, including conceptualization, information retrieval, data synthesis, and writing. Tammy Alexander, Virginia A Black, Elizabeth Clark, Lori K Cofano, Raul I Garcia, Anna Goddard, Jane Grover, Susan M Kansagra, Thomas E Kottke, Elizabeth C Lense, Tooka and Zokaie served as the coordination team for this review and provided critical input at each stage of the review process including manuscript review. The Community Preventive Services Task Force reviewed and provided critical input to the review protocol, presentation of findings, considerations for program implementation, and future research needs.

Journal Pre-proof

REFERENCES

1. US Department of Health and Human Services. *Oral Health in America: A Report of the Surgeon General.* US Dept of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health; 2000. Accessed: October 24, 2024. https://www.nidcr.nih.gov/sites/default/files/2017-10/hck1ocv.%40www.surgeon.fullrpt.pdf

2. Centers for Disease Control and Prevention. *Oral Health Surveillance Report: Trends in Dental Caries and Sealants, Tooth Retention, and Edentulism, United States, 1999–2004 to 2011–2016.* Centers for Disease Control and Prevention; 2019. Accessed: October 24, 2024. https://stacks.cdc.gov/view/cdc/154482/cdc_154482_DS1.pdf

3. Office of Disease Prevention and Health Promotion. (n.d.). Healthy People 2030. In: US Department of Health and Human Services. Accessed: October 24, 2024. https://odphp.health.gov/healthypeople

4. Clark MB, Keels MA, Slayton RL. Fluoride use in caries prevention in the primary care setting. *Pediatrics.* 2020;146(6). doi: https://doi.org/10.1542/peds.2020-034637

5. Marinho VC, Worthington HV, Walsh T, Clarkson JE. Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev.* 2013;2013(7): Cd002279. doiI: 10.1002/14651858.CD002279.pub2
.
6. Weyant RJ, Tracy SL, Anselmo TT, et al. Topical fluoride for caries prevention: executive summary of the updated clinical recommendations and supporting systematic review. *J Am Dent Assoc*. 2013;144(11):1279-1291. doi: 10.14219/jada.archive.2013.0057

7. Centers for Medicare & Medicaid Services. Core Set of Children's Health Care Quality Measures. 2022. Accessed: April 1, 2024. https://www.medicaid.gov/medicaid/quality-of-care/performance-measurement/adult-and-child-health-care-quality-measures/childrens-health-care-quality-measures/index.html

8. Chou R, Pappas M, Dana T, Selph S, Hart E, Fu R, et al. Screening and Interventions to Prevent Dental Caries in Children Younger Than Age Five Years: A Systematic Review for the U.S. Preventive Services Task Force. Evidence Synthesis No. 210. AHRQ Publication No. 21-05279-EF-1. Rockville, MD: Agency for Healthcare Research and Quality. Accessed February 26, 2025. Available from: https://www.ncbi.nlm.nih.gov/books/NBK575915/

9. Chou R, Bougatsos C, Griffin J, Selph SS, Ahmed A, Fu R, et al. Screening, Referral, Behavioral Counseling, and Preventive Interventions for Oral Health in Children and Adolescents Aged 5 to 17 Years: A Systematic Review for the US Preventive Services Task Force. JAMA 2023;330(17):1674-1686. doi: 10.1001/jama.2023.20435

10. Wei L, Griffin SO, Robison VA. Disparities in receipt of preventive dental services in children from low-income families. *Am J Prev Med.* 2018;55(3):e53-e60. doi: 10.1016/j.amepre.2018.04.039

11. Centers for Disease Control and Prevention. Oral Health Data. 2023. Accessed: April 1, 2024. https://www.cdc.gov/oralhealthdata/

Journal Pre-proof

12. Association of State and Territorial Dental Directors. Fluoride varnish: an evidence-based approach. 2014. Accessed: April 7, 2024. https://www.astdd.org/www/docs/fl-varnish-research-brief.pdf

13. Briss PA, Zaza S, Pappaioanou M, et al. Developing an evidence-based Guide to Community Preventive Services--methods. The Task Force on Community Preventive Services. *Am J Prev Med.* 2000;18(1 Suppl):35-43. doi: 10.1016/s0749-3797(99)00119-1

14. The Community Guide. Methods Manual for Community Guide Systematic Reviews. 2023. Accessed April 7, 2024 https://www.thecommunityguide.org/pages/methods-manual.html

15. Zaza S, Wright-De Agüero LK, Briss PA, Truman BI, Hopkins DP, Hennessy MH, et al. Data collection instrument and procedure for systematic reviews in the Guide to Community Preventive Services. Task Force on Community Preventive Services. *Am J Prev Med.* 2000;18(1 Suppl):44-74. doi: 10.1016/s0749-3797(99)00122-1

16. World Bank Country and Lending Groups. World Bank country classifications by income level: 2022-2023. Accessed: June 27, 2024. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

17. Abreu-Placeres N, Garrido LE, Castillo Jaquez I, Feliz-Matos LE. Does applying fluoride varnish every three months better prevent caries lesions in erupting first permanent molars? A randomised clinical trial. *Oral Health Prev Dent.* 2019;17(6):541-546. doi: https://dx.doi.org/10.3290/j.ohpd.a43566

18. Arruda AO, Senthamarai Kannan R, Inglehart MR, Rezende CT, Sohn W. Effect of 5% fluoride varnish application on caries among school children in rural Brazil: a randomized controlled trial. *Community Dent Oral Epidemiol*. 2012;40(3):267-276. doi: https://dx.doi.org/10.1111/j.1600-0528.2011.00656.x

19. Autio-Gold JT, Courts F. Assessing the effect of fluoride varnish on early enamel carious lesions in the primary dentition. *J Amer Dent Assoc.* 2001;132(9):1247-53. doi: 10.14219/jada.archive.2001.0367

20. Bergstrom EK, Birkhed D, Granlund C, Skold UM. Approximal caries increment in adolescents in a low caries prevalence area in Sweden after a 3.5-year school-based fluoride varnish programme with Bifluorid 12 and Duraphat. *Community Dent Oral Epidemiol.* 2014;42(5):404-411. doi: https://dx.doi.org/10.1111/cdoe.12108

21. Bergstrom EK, Lingstrom P, Hakeberg M, Gahnberg L, Skold UM. Caries and costs: an evaluation of a school-based fluoride varnish programme for adolescents in a Swedish region. *Community Dental Health.* 2016;33(2):138-144.

22. Braun PA, Quissell DO, Henderson WG, et al. A cluster-randomized, community-based, tribally delivered oral health promotion trial in Navajo Head Start children. *J Dent Res.* 2016;95(11):1237-1244. doi: https://dx.doi.org/10.1177/0022034516658612

Journal Pre-proof

23. Bravo M, Garcia-Anllo I, Baca P, Llodra JC. A 48-month survival analysis comparing sealant (Delton) with fluoride varnish (Duraphat) in 6- to 8-year-old children. *Community Dent Oral Epidemiol.* 1997;25(3):247-250. doi: 10.1111/j.1600-0528.1997.tb00935.x

24. Chu CH, Lo EC, Lin HC. Effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dentin caries in Chinese pre-school children. *J Dent Res.* 2002;81(11):767-70. doi: 10.1177/0810767

25. Clark DC, Stamm JW, Robert G, Tessier C. Results of a 32-month fluoride varnish study in Sherbrooke and Lac-Megantic, Canada. *J Am Dent Assoc*. 1985;111(6):949-953. doi: 10.14219/jada.archive.1985.0211

26. Dudovitz RN, Valiente JE, Espinosa G, et al. A school-based public health model to reduce oral health disparities. *J Public Health Dent.* 2018;78(1):9-16. doi: https://dx.doi.org/10.1111/jphd.12216

27. Effenberger S, Greenwall L, Cebula M, Myburgh N, Simpson K, Smit D, et al. Cost-effectiveness and efficacy of fluoride varnish for caries prevention in South African children: a cluster-randomized controlled community trial. *Community Dent Oral Epidemiol.* 2022;50(5):453-460. doi: https://doi.org/10.1111/cdoe.12702

28. Florio FM, Pereira AC, Meneghim Mde C, Ramacciato JC. Evaluation of non-invasive treatment applied to occlusal surfaces. *ASDC J Dent Child*. 2001;68(5-6):326-331, 301.

29. Grodzka K, Augustyniak L, Budny J, et al. Caries increment in primary teeth after application of Duraphat fluoride varnish. *Community Dent Oral Epidemiol.* 1982;10(2):55-59. doi: 10.1111/j.1600-0528.1982.tb00362.x

30. Hardman MC, Davies GM, Duxbury JT, Davies RM. A cluster randomised controlled trial to evaluate the effectiveness of fluoride varnish as a public health measure to reduce caries in children. *Caries Res.* 2007;41(5):371-6. doi: 10.1159/000104795

31. Hedman E, Gabre P, Birkhed D. Dental hygienists working in schools - a two-year oral health intervention programme in Swedish secondary schools. *Oral Health Prev Dent.* 2015;13(2):177-188. https://dx.doi.org/10.3290/j.ohpd.a32132

32. Jiang EM, Lo EC, Chu CH, Wong MC. Prevention of early childhood caries (ECC) through parental toothbrushing training and fluoride varnish application: a 24-month randomized controlled trial. *J Dent.* 2014;42(12):1543-1550. doi:https://dx.doi.org/10.1016/j.jdent.2014.10.002

33. Kidd JB, McMahon AD, Sherriff A, Gnich W, Mahmoud A, Macpherson LM, et al. Evaluation of a national complex oral health improvement programme: a population data linkage cohort study in Scotland. *BMJ Open.* 2020;10(11):e038116. doi: https://dx.doi.org/10.1136/bmjopen-2020-038116

34. Liu BY, Lo EC, Chu CH, Lin HC. Randomized trial on fluorides and sealants for fissure caries prevention. *J Dent Res.* 2012;91(8):753-758. doi: https://dx.doi.org/10.1177/0022034512452278

35. McMahon AD, Wright W, Anopa Y, et al. Fluoride Varnish in Nursery Schools: A Randomised Controlled Trial - Protecting Teeth @3. *Caries Res.* 2020;54(3):274-282. doi: https://dx.doi.org/10.1159/000509680

Journal Pre-proof

36. Milsom KM, Blinkhorn AS, Walsh T, et al. A cluster-randomized controlled trial: fluoride varnish in school children. *J Dent Res.* 2011;90(11):1306-1311. doi: 10.1177/0022034511422063

37. Moberg Skold U, Petersson LG, Lith A, Birkhed D. Effect of school-based fluoride varnish programmes on approximal caries in adolescents from different caries risk areas. *Caries Res.* 2005;39(4):273-279. doi: 10.1159/000084833

38. Modeer T, Twetman S, Bergstrand F. Three-year study of the effect of fluoride varnish (Duraphat) on proximal caries progression in teenagers. *Scand J Dent Res.* 1984;92(5):400-407. doi: 10.1111/j.1600-0722.1984.tb00908.x

39. Munoz-Millan P, Zaror C, Espinoza-Espinoza G, Vergara-Gonzalez C, Munoz S, Atala-Acevedo C, et al. Effectiveness of fluoride varnish in preventing early childhood caries in rural areas without access to fluoridated drinking water: a randomized control trial. *Community Dent Oral Epidemiol.* 2018;46(1):63-69. doi: https://dx.doi.org/10.1111/cdoe.12330

40. Pitchika V, Kokel CJ, Andreeva J, Crispin A, Hickel R, Kuhnisch J, et al. Effectiveness of a new fluoride varnish for caries prevention in pre-school children. *J Clin Pediatr Dent.* 2013;38(1):7-12. doi: 10.17796/jcpd.38.1.8189243pt1m6t716

41. Sirivichayakul P, Jirarattanasopha V, Phonghanyudh A, Tunlayadechanont P, Khumsub P, Duangthip D. The effectiveness of topical fluoride agents on preventing development of approximal caries in primary teeth: a randomized clinical trial. *BMC Oral Health.* 2023;23(1):349. doi: 10.1186/s12903-023-03045-4

42. Souza BM, Silva MS, Braga AS, Santos D, Carvalho TS, Santos NMD, et al. Acceptability and effect of TiF4 on dental caries: a randomized controlled clinical trial. *Braz Oral Res.* 2021;35:e121. doi: https://dx.doi.org/10.1590/1807-3107bor-2021.vol35.0121

43. Tagliaferro EP, Pardi V, Ambrosano GM, Meneghim Mde C, da Silva SR, Pereira AC. Occlusal caries prevention in high and low risk schoolchildren. A clinical trial. *Am J Dent.* 2011;24(2):109-114.

44. Turska-Szybka A, Gozdowski D, Twetman S, Olczak-Kowalczyk D. Clinical effect of two fluoride varnishes in caries-active preschool children: a randomized controlled trial. *Caries Res.* 2021;55(2):137-143. doi: 10.1159/000514168

45. Wang Z, Rong W, Xu T. Effect of fluoride varnish in caries prevention on permanent first molars: a 36-month cluster randomized controlled trial. *Ped Dent.* 2021;43(2):82-87.

46. Wu S, Zhang T, Liu Q, Yu X, Zeng X. Effectiveness of fluoride varnish on caries in the first molars of primary schoolchildren: a 3-year longitudinal study in Guangxi Province, China. *Int Dent J.* 2020;70(2):108-115. doi: https://dx.doi.org/10.1111/idj.12528

47. Zimmer S, Robke FJ, Roulet JF. Caries prevention with fluoride varnish in a socially deprived community. *Community Dent Oral Epidemiol.* 1999;27(2):103-108. doi: 10.1111/j.1600-0528.1999.tb01998.x

Journal Pre-proof

48. Association of State and Territorial Dental Directors. Fluoride Varnish Policy Statement. 2015. Accessed: April 1, 2024. https://www.astdd.org/docs/fluoride-varnish.pdf

49. Rebelo MAB, Rebelo Vieira JM, Pereira JV, Quadros LN, Vettore MV. Does oral health influence school performance and school attendance? A systematic review and meta-analysis. *Int J Paediatr Dent.* 2018. doi: 10.1111/ipd.12441

50. Ruff RR, Senthi S, Susser SR, Tsutsui A. Oral health, academic performance, and school absenteeism in children and adolescents: a systematic review and meta-analysis. *J Am Dent Assoc.* 2019;150(2):111-121.e4. doi: 10.1016/j.adaj.2018.09.023

51. Ruff RR, Habib R, Godin TB, Niederman R. School-based caries prevention and the impact on acute and chronic student absenteeism. J Am Dent Assoc 2023;154(8):753-759. doi: 10.1016/j.adaj.2023.05.007

52. Dos Santos AP, Malta MC, de Marsillac MW, de Oliveira BH. Fluoride varnish applications in preschoolers and dental fluorosis in permanent incisors: results of a nested-cohort study within a clinical trial. *Pediatr Dent.* 2016;38(5):414-418.

53. Patel N, Griffin SO, Linabarger M, Lesaja S. Impact of school sealant programs on oral health among youth and identification of potential barriers to implementation. *J Am Dent Assoc.* 2022;153(10):970-978.e4. doi: 10.1016/j.adaj.2022.05.011

54. American Academy of Pediatrics. Medicaid payment of preventive oral health services. 2024. Accessed: June 27, 2024. https://www.aap.org/en/patient-care/oral-health/payment-for-oral-health-services/

55. Indian Health Service. Topical Fluoride Treatments. 2014. Accessed: March 29, 2024. https://www.ihs.gov/doh/hpdp/documents/GPRA/TopicalFluorideTreatments.pdf

56. Indian Health Service. Head Start's Role in ECC Prevention & Early Intervention 2010. Accessed: March 29, 2024. https://www.ihs.gov/doh/documents/ecc/CommunityDocs/HeadStartRoleECCPreventionAndIntervention.pdf

57. Holve S. Fluoride varnish applied at well child care visits can reduce early childhood caries. *IHS Prim Care Provid.* 2006;31(10):243-245. doi: 10.1007/s10995-007-0294-0

Journal Pre-proof

FIGURE TITLES AND FOOTNOTES

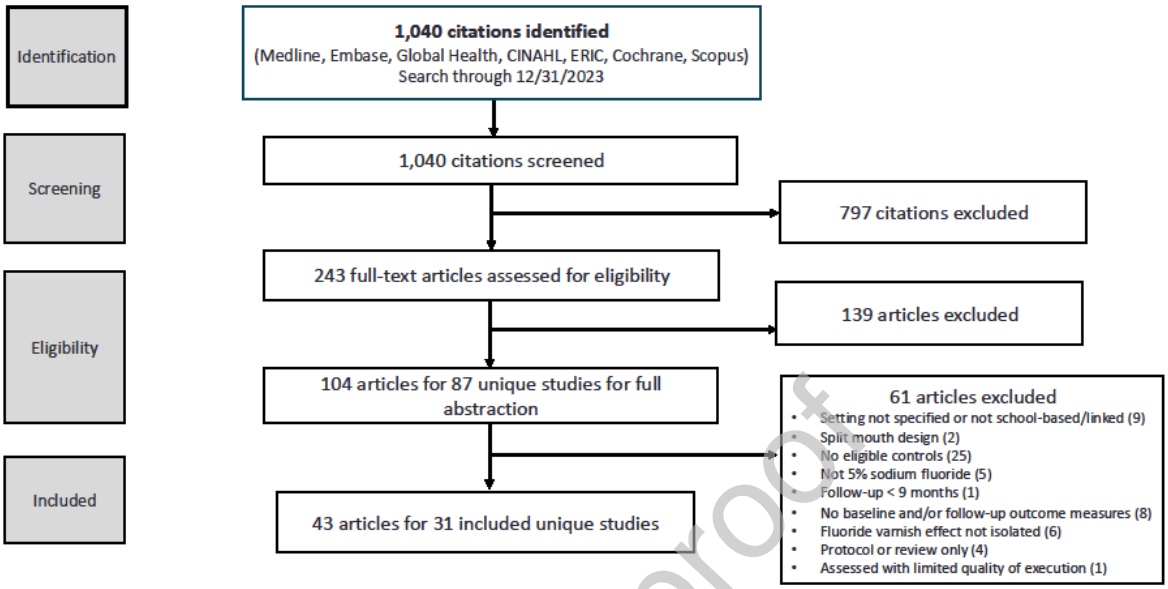

Figure 1. Search yield for included studies

Journal Pre-proof

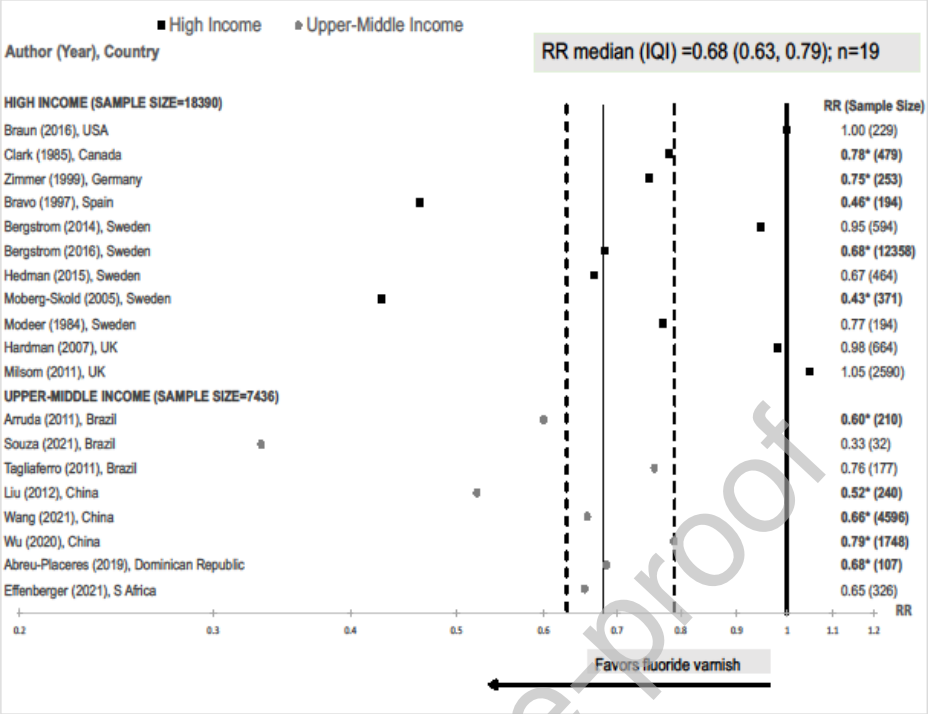

Figure 2. Effectiveness of SFVDP relative to no program on caries initiation in permanent teeth

IQI: Inter-quartile interval. n: Number of studies. RR: Relative risk/ratio. SFVDP: School fluoride varnish delivery programs. X-axis is in log-scale. Thin solid bar represents the median and dashed bars the IQI.* Significant effect at $p<0.05$ for RR, odds ratio, prevented fraction, difference in incidence or increment for SFVDP vs control, or $p>0.05$ at baseline and $p<0.05$ at follow-up for SFVDP vs control.

Journal Pre-proof

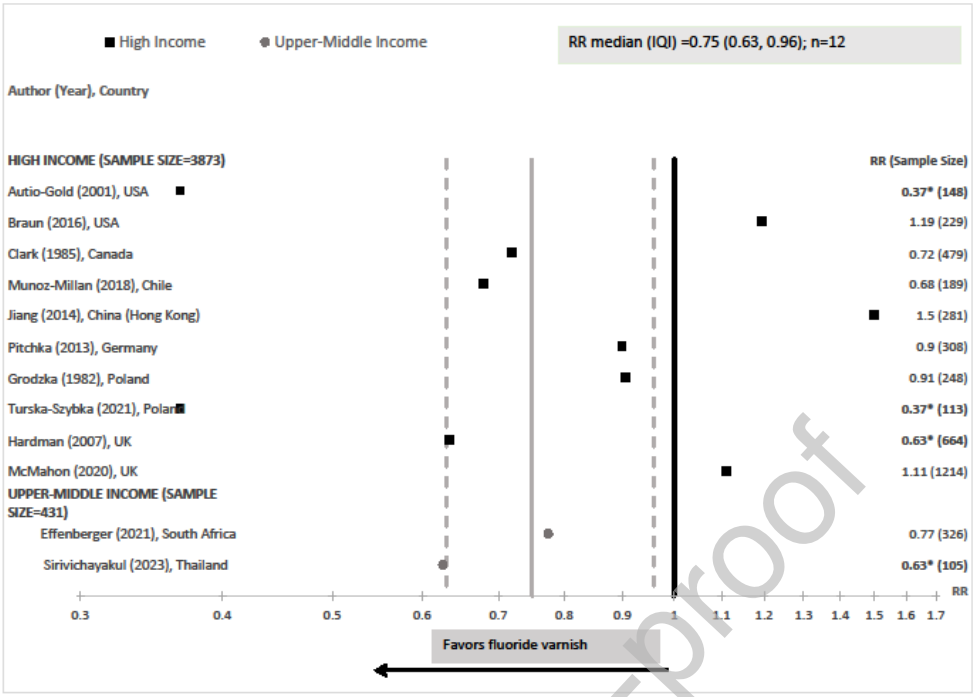

Figure 3. Effectiveness of SFVDP relative to no program on caries initiation in primary teeth

IQI: Inter-quartile interval. n: Number of studies. RR: Relative risk/ratio. SFVDP: School fluoride varnish delivery programs. X-axis is in log-scale. Thin solid bar represents the median and dashed bars the IQI.* Significant effect at $p<0.05$ for RR, difference in incidence or increment for SFVDP vs control, or $p>0.05$ at baseline and $p<0.05$ at follow-up for SFVDP vs control.

Journal Pre-proof

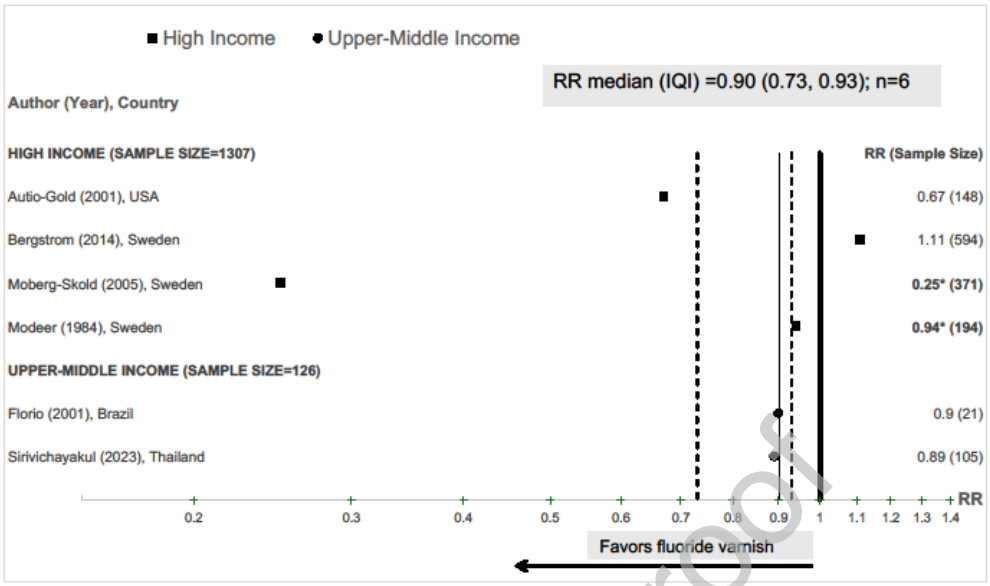

Figure 4. Effectiveness of SFVDP relative to no program on caries progression

RR: Relative risk/ratio. IQI: Inter-quartile interval. n: Number of studies. SFVDP: School fluoride varnish delivery programs. X-axis is in log scale. Thin solid bar represents the median and dashed bars the IQI. * Significant effect at $p<0.05$ for difference in incidence or increment for SFVDP vs control.

CRediT statement:

Susan O Griffin, Mei Lin, Christina R Scherrer, Shillpa Naavaal, Anita A Jones, and David Hopkins: conceptualization, investigation, formal synthesis, writing – original draft, and writing – review & editing. **Tammy Alexander, Virginia A Black, Elizabeth Clark, Lori K Cofano, Raul I Garcia, Anna Goddard, Jane Grover, Susan M Kansagra, Thomas E Kottke, Elizabeth C Lense, Tooka Zokaie**: Validation and writing – review & editing. **The Community Preventive Services Task Force**: Validation.

Journal Pre-proof