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Preventive Oral Health Interventions: *A Review of the Evidence*

The Washington State Legislature directed the Washington State Institute for Public Policy (WSIPP) to "calculate the return on investment to taxpayers from evidence-based prevention and intervention programs and policies."[1] Additionally, WSIPP's Board of Directors authorized WSIPP to work on a joint project of the MacArthur Foundation and the Pew Charitable Trusts to extend WSIPP's benefit-cost analysis to certain public health, health care, and other topics.

As part of the Pew-MacArthur Results First Initiative, preventive dental care was identified as an important public health issue, with potential net savings to states. In Washington State, dental care represents significant expenditures in Medicaid, public employees' benefits, and in agencies such as the Department of Corrections. The goal of this study was to identify evidence-based ways to prevent or reduce some of these costs.

This report presents a summary of the evidence of the effectiveness of three oral health interventions.

Summary

WSIPP's Board of Directors authorized WSIPP to work on a joint project of the MacArthur Foundation and the Pew Charitable Trusts to extend WSIPP's benefit-cost analysis to certain public health, health care, and other topics.

The Pew-MacArthur Results First Initiative identified preventive dental care as an important public health issue that may have long-term implications in Medicaid and other health care expenses.

WSIPP conducted literature reviews on five dental topics: fluoride varnish, sealants, community water fluoridation, mid-level dental providers, and preventive dental visits. We found sufficient rigorous evaluations to analyze the effect of three of the five oral health interventions on tooth decay: fluoride varnish, sealants, and community water fluoridation.

We found that all three interventions decrease tooth decay in youth, although the analysis of community water fluoridation was based on only two rigorous studies. These studies did not measure other outcomes of interest, such as dental and medical services use, bone development, and fluorosis.

We also did not find sufficient research quantifying the link between youth tooth decay and long-term health and economic outcomes. Therefore, we were not able to complete a benefit-cost analysis of these interventions at this time.

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[1] Laws of 2009, Ch. 564, § 610 (4), ESHB 1244.

I. Oral Health in Washington

Tooth decay is one of the most common diseases among children. More than half the children in Washington have experienced tooth decay by third grade (Exhibit 1).[2] Children from disadvantaged backgrounds and those from racial and ethnic minority groups experience more tooth decay than their peers.

Tooth decay continues to impact individuals throughout their lifetime. For example, tooth decay is a common reason for tooth extraction.[3] In Washington, 39% of people at least 18 years of age had at least one tooth extracted and 11% of adults at least 65 years of age have had all of their natural teeth extracted.[4]

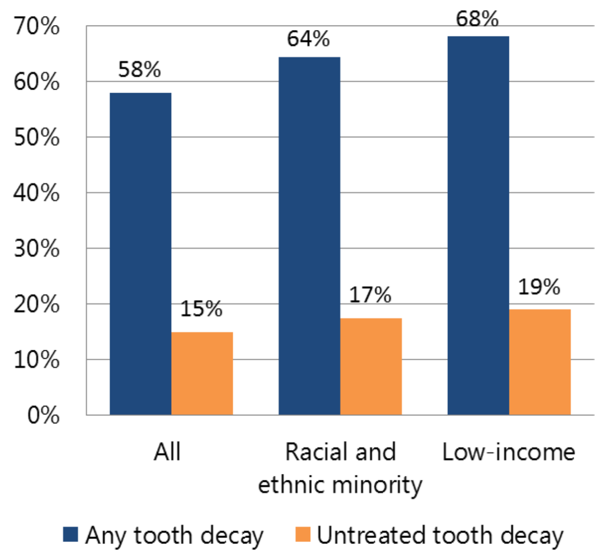
Washington State funds dental care for some people through Medicaid, the Public Employees Benefit Board, and agencies such as the Department of Corrections. Exhibit 2 presents information about each of these state resources for dental care.

Additionally, the Washington State Department of Health promotes oral health by licensing dental professionals, disseminating oral health education and resource materials, collecting surveillance data, and monitoring the most common dental public health intervention—water fluoridation.

Local governments, however, make the decision of whether or not to add fluoride to the public water supply. In 2012, 63% of residents using community water systems in Washington received fluoridated water.[5]

Exhibit 1

Percentage of 3rd grade students with tooth decay in Washington State



Source: Washington State Department of Health, 2011. Percentages include decay in primary and permanent teeth.

[2] Washington State Department of Health. (2011). *Washington State Smile Survey 2010.* Retrieved from http://www.doh.wa.gov/YouandYourFamily/OralHealth
[3] Other reasons for tooth extraction include trauma and periodontal (gum) disease.
[4] Centers for Disease Control and Prevention. (2014). *Prevalence and trends data, Washington 2012.* Retrieved from http://apps.nccd.cdc.gov/brfss/page.asp?yr=2012&state=WA&cat=OH#OH

[5] Center for Disease Control. (2012). *2012 water fluoridation statistics.* Retrieved from http://www.cdc.gov/fluoridation/statistics/2012stats.htm

Exhibit 2

Washington State Dental Benefits

Provided by	Eligible population	Number of individuals who received services	Cost of dental services
Medicaid (also known as Apple Health)	Medicaid is jointly funded by states and the federal government. Medicaid currently provides dental coverage for both children and adults.[a]	533,939 (FY 2012, adults receiving Medicaid did not have dental benefits at this time)[b]	$237 million (FY 2012, includes federal match)[c]
Public Employees Benefit Board	State employees receive dental coverage with no premium for a choice of plans that costs the state approximately $39-$45 per person per month.[d] Employees can purchase dental coverage for their dependents by paying the additional cost of a family plan.[e]	*Employees* 132,856 (FY 2014) *Dependents* 123,763 (FY 2014)[f]	*Employees* $75 million (FY 2014) *Dependents* $135 million (FY 2014)[g]
Department of Corrections	States are constitutionally mandated to provide health care to inmates. The DOC provides "medically necessary dental care."[h]	14,336 (FY 2014)[i]	$7 million (FY 2014)[j]

[a] Dental benefits were restored for adults receiving Medicaid in January 2013.
[b] Washington State Health Care Authority. (2014). *Dental data*. Retrieved from http://www.hca.wa.gov/medicaid/dentalproviders/pages/dental_data.aspx
[c] Washington State Health Care Authority, 2014. Dollar amounts are rounded to the nearest million.
[d] Beth Heston, Washington State Health Care Authority (personal communication, October 7, 2014).
[e] Ibid. Family plans cost approximately $79-$135 total per month depending on the type of plan and the family members covered.
[f] Ibid.
[g] Ibid. Dollar amounts are rounded to the nearest million.
[h] Washington State Department of Corrections. (2014). *Offender Health Plan*. Retrieved from http://www.doc.wa.gov/family/offenderlife/healthservices.asp
[i] Mary Jo Currey, Washington State Department of Corrections (personal communication, August 27, 2014)
[j] Ibid. Dollar amounts are rounded to the nearest million.

II. Research Approach

When WSIPP is asked by the legislature to identify what works (and what does not) in public policy, we implement a three-step research approach.

- Step 1: What works? What does not?
- Step 2: What makes economic sense?
- Step 3: What is the risk in the benefit-cost findings?

In this report, we focus on the first research step. We estimate whether various oral health interventions can achieve the desired outcome—the prevention of tooth decay.[6] We carefully analyze all high-quality studies from the United States and elsewhere to identify policy options tried, tested, and found to impact outcomes. We look for research studies with strong evaluation designs and exclude studies with weak research methods.

Our empirical approach then follows a meta-analytic framework to assess systematically all credible evaluations we can locate on a given topic. Given the weight of the evidence, we calculate an average expected effect of a policy on a particular outcome of interest, as well as an estimate of the margin of error for that effect. We describe this method in detail in WSIPP's Technical Documentation.[7]

Whenever possible, WSIPP conducts a benefit-cost analysis for an intervention using the effect sizes calculated in the meta-analysis.

We searched the dental and economic literature for studies linking tooth decay to outcomes such as medical complications, emergency department use, inadequate nutrition, academic performance, labor market earnings, and the need for restorative and emergency dental procedures. We did not find sufficient rigorous research to establish a cause-and-effect relationship between tooth decay in youth and outcomes that can be monetized over an individual's lifetime. Therefore, we could not conduct a benefit-cost analysis.

[6] For this report we only include studies where outcomes are assessed by a clinician who is "blinded" (does not know who is and is not receiving treatment) when blinding was possible. Blinding was not always possible in studies examining sealants since sealants that are still attached to a tooth are often visible.

[7] Washington State Institute for Public Policy (2014). *Benefit-cost technical documentation.* Olympia, WA: Author. Retrieved from http://www.wsipp.wa.gov/TechnicalDocumentation/WsippBenefitCostTechnicalDocumentation.pdf

III. Research Results

Literature Review

WSIPP identified dental topics for analysis based on published recommendations from the U.S. Preventive Task Force and the Washington State Board of Health.[8] We also consulted the Pew Charitable Trusts' Children's Dental Policy team and Washington State Department of Health's Oral Health Program.

We conducted literature reviews on sealants, fluoride varnish, community water fluoridation, mid-level dental providers, and preventive dental visits. We found sufficient rigorous studies that measured patient-level outcomes to conduct a meta-analysis on three topics:[9]

- fluoride varnish compared to no treatment,
- resin sealants on permanent molars compared to no treatment, and
- community water fluoridation.

Exhibit 3 describes these topics in greater detail. The studies measured only one outcome—tooth decay. None of the studies measured other outcomes of interest such as the use of dental and medical services, bone development, and fluorosis.[10]

Since almost all of the rigorous studies on these topics evaluated the interventions on children and adolescents, we focused our analysis on youth. Children can experience tooth decay in their primary or permanent teeth. The fluoride varnish studies measured the effect of the intervention on both primary and permanent teeth. The evaluations of community water fluoridation and sealants only measured the interventions' impact on permanent teeth.

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[8] U.S. preventive Task Force. (2014). *Published Recommendations*. Retrieved from http://www.uspreventiveservicestaskforce.org/BrowseRec/Index/browse-recommendations; Washington State Board of Health. (2014). *Recommended strategies to improve the oral health of Washington residents*. Retrieved from http://sboh.wa.gov/OurWork/CurrentProjects/OralHealthStrategies

[9] Citations for all studies that we reviewed are listed in the Technical Appendix.

[10] Fluorosis is discoloration in a tooth's enamel because of overexposure to fluoride. The association between bone development and fluorosis has been examined in relationship to total fluoride exposure in Levy et al., 2009 and Hong et al., 2006. These studies, however, do not differentiate between fluoride that is ingested and fluoride that is not (e.g., toothpaste or mouthwash). Levy, S.M., Eichenberger-Gilmore, J., Warren, J.J., Letuchy, E., Broffitt, B., Marshall, T.A., ... Torner, J.C. (2009). Associations of fluoride intake with children's bone measures at age 11. *Community Dentistry and Oral Epidemiology, 37*(5), 416-426. Hong, L., Levy, S.M., Warren, J.J., Broffitt, B., & Cavanaugh, J. (2006). Fluoride intake levels in relation to fluorosis development in permanent maxillary central incisors and first molars. *Caries Research, 40*(6), 494-500.

Exhibit 3

Description of Oral Health Outcomes and Interventions

Tooth decay

Tooth decay (also called dental caries or cavities) is caused by an infection that results in the destruction of tooth tissue. In this report we focus on decay that had reached the dentin (middle) layer of the tooth.

Fluoride varnish

Fluoride varnish is a form of fluoride that temporarily adheres to the tooth in order to maintain contact between the fluoride and the tooth for several hours. In the studies we reviewed, fluoride varnish was applied every three to six months over a 12- to 36-month time period.

Sealants

Sealants are plastic films applied to the biting surfaces of molars to prevent decay. Approximately 51% of 3rd grade students in Washington have sealants.[#] Our analysis focuses on comparing the effectiveness of resin sealants to no treatment. We also examined the effectiveness of other sealant materials compared to resin sealants and we report these results in the Technical Appendix.

Community water fluoridation

Water contains naturally occurring fluoride at varying levels. Community water fluoridation refers to the addition of a fluoride compound to the public water supply to achieve a total fluoride level of 0.7-1.2 mg/L.

[#] Washington State Department of Health, 2011.

Meta-Analysis Findings

Fluoride varnish. Eleven out of 17 studies evaluating fluoride varnish on permanent teeth and five out of the eight studies on fluoride varnish on primary teeth met WSIPP's criteria for scientific rigor. These studies contributed 14 effect sizes to the meta-analysis of fluoride varnish on permanent teeth and six effect sizes to the meta-analysis of fluoride varnish on primary teeth.

We found that fluoride varnish significantly reduces tooth decay in both primary and permanent teeth (Exhibit 4). Given the study population and calculated effect size, we would expect that 25% of permanent molars would have developed decay without fluoride varnish and 18% would have developed decay with fluoride varnish.[11] Similarly, we would expect that 25% of primary molars would have developed decay without fluoride varnish and 19% would have developed decay with fluoride varnish.

Resin sealants. Ten out of the 11 studies that evaluated the application of resin sealants on permanent molars, compared to no treatment, met WSIPP's criteria for scientific rigor. These rigorous studies contributed 12 effect sizes to the meta-analysis.

We found that the application of resin sealants significantly decreases tooth decay on permanent molars (Exhibit 4). Given the study population and calculated effect size, we would expect that 25% of molars would have developed decay without resin sealants and 6% would have developed decay with resin sealants.

We did not find a statistically significant difference between the performance of resin sealants and sealants of other materials (Technical Appendix, Exhibit A1). However, the analysis suggests that, on average, resin-modified glass ionomer sealants tend to perform better than resin sealants.[12]

Community water fluoridation. Unfortunately, only two out of 11 studies we located on community water fluoridation's impact on youth met WSIPP's criteria for scientific rigor. The excluded studies either did not have an adequate comparison group or analyzed the impact of fluoride exposure from all sources including toothpaste and mouthwash.

The two included studies measured the effect of community fluoridation for approximately four years on children who were an average of ten years old when the studies began. Our results, therefore, do not reflect the effectiveness of community water fluoridation on younger and older members of the community who would also be exposed to this intervention.

[11] Since we could not find epidemiologic data describing the incidence of tooth decay, we estimated the incidence of tooth decay in molars using the average rate of tooth decay in the control groups of the studies that were included in this report. In the dental interventions that we reviewed, 25% of permanent teeth in the control group developed tooth decay over an average follow up period of 31 months.

[12] This comparison approached statistical significance (p-value=0.108).

Exhibit 4

Meta-Analytic Results for Three Oral Health Interventions

	Number of studies reviewed	Number of studies included	Number of effect sizes	Average age of partici-pant	Follow up period (months)	Average effect size****	Decay rate in compar-ison group	Estimated decay rate with intervention
Permanent teeth								
Fluoride varnish*	17	11	14	8	31	-0.272**	25%***	18%***
Resin sealants on molars compared to no treatment	11	10	12	8	24	-0.981**	25%	6%
Community water fluoridation	11	2	2	10	47	-0.560**	25%	12%
Primary teeth								
Fluoride varnish*	8	5	6	6	26	-0.211**	25%***	19%***

* Fluoride varnish is typically applied to all teeth. However, the studies that we included measured decay on different surfaces of interest: all teeth, proximal surfaces, molars, and surfaces with initial decay.
** Results are statistically significant based on a p-value of $\leq$ 0.05.
*** Our estimate of the decay rate in the comparison group and intervention group is for molars only. We did not have enough data to estimate the decay rate in the comparison group for each tooth surface measured in the studies that we included in the meta-analysis.
**** The average effect size weighted by inverse variance weights from a random effects meta-analysis. See the Technical Documentation for detailed methods. http://www.wsipp.wa.gov/TechnicalDocumentation/WsippBenefitCostTechnicalDocumentation.pdf

We found a significant decrease in tooth decay with community water fluoridation for this specific age group (Exhibit 4). Given the study population and calculated effect size, we would expect that 25% of molars would have developed decay without community water fluoridation and 12% of molars would have developed tooth decay with this intervention. We caution, however, that this finding is based on just two rigorous studies.

IV. Conclusions

We found that sealants and fluoride varnish significantly reduce tooth decay in youth.

We also found that community water fluoridation reduces tooth decay in youth, although this finding is based on only two studies. Additional research is needed to fully characterize the impact of community water fluoridation. This research should include a range of age groups and measure other outcomes of interest.

We did not conduct a benefit-cost analysis on preventive dental interventions for youth because of a lack of longitudinal research on the economic and health consequences of youth tooth decay.

Technical Appendix

Preventive Oral Health Interventions: A Review of the Evidence

WSIPP's meta-analytic methods are described in detail in our Technical Documentation.[13] This Technical Appendix describes the methodology specific to preventive oral health topics.

A1. Meta-Analysis Methodology: Adjusting for Clustering

Many dental studies report data that are clustered. For example, outcomes may be reported for individual teeth which are clustered within a person. Analyses that do not account for clustering will underestimate the variance in outcomes at the tooth level and, thus, may over-estimate the precision of magnitude on effect sizes. In studies that do not account for clustering, effect sizes and their variance require additional adjustments.[14] We describe these adjustments in detail in WSIPP's Technical Documentation.[15]

In the dental literature we found two types of clustering: children clustered within schools and teeth clustered within an individual person. We used 2006 Washington Assessment of Student Learning (WASL) data to calculate values of the intraclass correlation coefficient (ρ) for the school-level clustering (ρ = 0.114).

When the unit of analysis was a tooth and data were reported as tooth pairs we used the binary correlation coefficient as the intraclass correlation coefficient. We calculated the binary correlation coefficient using the following method described by Elbourne et al., 2002:[16]

$$\rho = \frac{ns - ab}{\sqrt{abcd}}$$

[13] Washington State Institute for Public Policy (2014). *Benefit-cost technical documentation.* Olympia, WA: Author. http://www.wsipp.wa.gov/TechnicalDocumentation/WsippBenefitCostTechnicalDocumentation.pdf

[14] Studies that employ hierarchical linear modeling, fixed effects with robust standard errors, or random effects models account for variance and need no further adjustment for computing the effect size, but adjustments are made to the inverse variance weights for meta-analysis using these methods.

[15] Washington State Institute for Public Policy, 2014.

[16] Elbourne, D.R., Altman, D.G., Higgins, J.P., Curtin, F., Worthington, H.V., & Vail, A. (2002). Meta-analyses involving cross-over trials: methodological issues. *International Journal of Epidemiology, 31*(1), 140-149.

where n is the total number of treatment and control units, a is the number of successful outcomes in the treatment group, b is the number of successful outcomes in the control group, c is the number of unsuccessful outcomes in the treatment group, and d is the number of unsuccessful outcomes in the control group. If data were not reported as tooth pairs, we used the mean binary correlation coefficient of the studies where it could be calculated.

A2. Meta-Analysis Methodology: Adjusting Effect Sizes for Research Design, Study Population, Study Setting, and Control Group

In this analysis we considered adjusting effect sizes for the following reasons: research design, high-risk study population, and the use of a placebo control group. For a full description of the rationale for these types of adjustments see the WSIPP Technical Documentation.[17]

Since there was little variation in the research design we were not able to investigate whether this factor produced systematically different effect sizes. We conducted a meta-regression to assess whether testing the intervention in a high-risk population or using a placebo treatment in the control group yielded systematically different effect sizes. We did not find any statistically significant differences based on these attributes and, therefore, present the unadjusted effect sizes in this report.

A3. Meta-Analyses of Sealants of Different Materials

We identified 12 rigorous studies that evaluated resin sealants on permanent molars compared to no treatment. We also identified rigorous studies that evaluated sealants of different materials compared to resin sealants (Exhibit A1).

We list the citations to all studies included in these meta-analyses at the end of this Technical Appendix.

Exhibit A1

Meta-Analytic Results of Tooth Decay with Different Sealant Materials Compared to Resin Sealants

Materials compared	No. of effect sizes	Effect sizes at two year follow-up		
		ES	SE	p-value
Glass-ionomer sealants (earlier generation, e.g., Fuji III) compared to resin sealants	7	-0.016	0.208	0.938
High viscosity glass-ionomer sealants compared to resin sealants	3	0.096	0.235	0.683
Poly-acid modified resin composite sealants compared to resin sealants	3	-0.075	0.151	0.620
Resin-modified glass ionomer sealants compared to resin sealants	4	0.304	0.189	0.108

[17] Washington State Institute for Public Policy (2014). Benefit-cost technical documentation. Olympia, WA: Author. http://www.wsipp.wa.gov/TechnicalDocumentation/WsippBenefitCostTechnicalDocumentation.pdf

A4. Reviewed Studies Included in the Meta-Analyses

Resin sealants compared to no treatment

Bravo, M., Llodra, J.C., Baca, P., & Osorio, E. (1996). Effectiveness of visible light fissure sealant (Delton) versus fluoride varnish (Duraphat): 24-month clinical trial. *Community Dentistry and Oral Epidemiology*, *24*(1), 42-46.

Brooks, J.D., Mertz-Fairhurst, E.J., Della-Giustina, V.E., Williams, J.E., & Fairhurst, C.W. (1979). A comparative study of two pit and fissure sealants: two-year results in Augusta, GA. *Journal of the American Dental Association*, *98*(5), 722-725.

Charbeneau, G.T., & Dennison, J.B. (1979). Clinical success and potential failure after single application of a pit and fissure sealant: a four-year report. *Journal of the American Dental Association*, *98*(4), 559-564.

Hunter, P.B. (1988). A study of pit and fissure sealing in the School Dental Service. *The New Zealand Dental Journal*, *84*(375), 10-12.

Liu, B.Y., Lo, E.C., Chu, C.H., & Lin, H.C. (2012). Randomized trial on fluorides and sealants for fissure caries prevention. *Journal of Dental Research, 91*(8), 753-758.

McCune, R.J., Bojanini, J., & Abodeely, R.A. (1979). Effectiveness of a pit and fissure sealant in the prevention of caries: three-year clinical results. *Journal of the American Dental Association, 99*(4), 619-623.

Richardson, A.S., Waldman, R., Gibson, G.B., & Vancouver, B.C. (1978). The effectiveness of a chemically polymerized sealant in preventing occlusal caries: two year results. *Dental Journal*, *44*(6), 269-272.

Rock, W.P., Gordon, P.H., & Bradnock, G. (1978). The effect of operator variability and patient age on the retention of fissure sealant resin. *British Dental Journal*, *145*(3), 72-75.

Sheykholeslam, Z., & Houpt, M. (1978). Clinical effectiveness of an autopolymerized fissure sealant after 2 years. *Community Dentistry and Oral Epidemiology*, *6*(4), 181-4.

Songpaisan, Y., Bratthall, D., Phantumvanit, P., & Somridhivej, Y. (1995). Effects of glass ionomer cement, resin-based pit and fissure sealant and HF applications on occlusal caries in a developing country field trial. *Community Dentistry and Oral Epidemiology*, *23*(1), 25-29.

Fluoride varnish on permanent teeth

Bravo, M., Llodra, J.C., Baca, P., & Osorio, E. (1996). Effectiveness of visible light fissure sealant (Delton) versus fluoride varnish (Duraphat): 24-month clinical trial. *Community Dentistry and Oral Epidemiology*, 24(1), 42-46.

Clark, D.C., Stamm, J.W., Robert, G., & Tessier, C. (1985). Results of a 32-month fluoride varnish study in Sherbrooke and Lac-Megantic, Canada. *Journal of the American Dental Association*, *111*(6), 949-53.

Hardman, M.C., Davies, G.M., Duxbury, J.T., & Davies, R.M. (2007). A cluster randomised controlled trial to evaluate the effectiveness of fluoride varnish as a public health measure to reduce caries in children. *Caries Research, 41*(5), 371-376.

Holm, G.B., Holst, K., & Mejàre, I. (1984). The caries-preventive effect of a fluoride varnish in the fissures of the first permanent molar. *Acta Odontologica Scandinavica, 42*(4), 193-197.

Koch, G., & Petersson, L.G. (1975). Caries preventive effect of a fluoride-containing varnish (Duraphat) after 1 year's study. *Community Dentistry and Oral Epidemiology, 3*(6), 262-266.

Liu, B.Y., Lo, E.C., Chu, C.H., & Lin, H.C. (2012). Randomized trial on fluorides and sealants for fissure caries prevention. *Journal of Dental Research, 91*(8), 753-758.

Milsom, K.M., Blinkhorn, A.S., Walsh, T., Worthington, H.V., Kearney-Mitchell, P., Whitehead, H., & Tickle, M. (2011). A cluster-randomized controlled trial: fluoride varnish in school children. *Journal of Dental Research, 90*(11), 1306-1311.

Modeer, T., Twetman, S., & Bergstrand, F. (1984). Three-year study of the effect of fluoride varnish (Duraphat) on proximal caries progression in teenagers. *European Journal of Oral Sciences, 92*(5), 400-407.

Skold, U.M., Petersson, L.G., Lith, A., & Birkhed, D. (2005). Effect of school-based fluoride varnish programmes on approximal caries in adolescents from different caries risk areas. *Caries Research, 39*(4), 273-279.

Tagliaferro, E.P., Pardi, V., Ambrosano, G.M., Meneghim, M.C., da, S.S.R., & Pereira, A. C. (2011). Occlusal caries prevention in high and low risk schoolchildren. A clinical trial. *American Journal of Dentistry, 24*(2), 109-114.

Tewari, A., Chawla, H. S., & Utreja, A. (1991). Comparative evaluation of the role of NaF, APF & Duraphat topical fluoride applications in the prevention of dental caries--a 2 1/2 years study. *Journal of the Indian Society of Pedodontics and Preventive Dentistry, 8*(1), 28-35.

Fluoride varnish on primary teeth

Chu, C.H., Lo, E.C., & Lin, H.C. (2002). Effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dentin caries in Chinese pre-school children. *Journal of Dental Research, 81*(11), 767-770.

Clark, D.C., Stamm, J.W., Robert, G., & Tessier, C. (1985). Results of a 32-month fluoride varnish study in Sherbrooke and Lac-Megantic, Canada. *Journal of the American Dental Association, 111*(6), 949-53.

Frostell, G., Birkhed, D., Edwardsson, S., Goldberg, P., Petersson, L.-G., Priwe, C., & Winholt, A.-S. (1991). Effect of partial substitution of invert sugar for sucrose in combination with Duraphat® treatment on caries development in preschool children: The Malmö study. *Caries Research, 25*(4), 304-310.

Hardman, M.C., Davies, G.M., Duxbury, J.T., & Davies, R.M. (2007). A cluster randomised controlled trial to evaluate the effectiveness of fluoride varnish as a public health measure to reduce caries in children. *Caries Research, 41*(5), 371-376.

Holm, A. (1979). Effect of a fluoride varnish (Duraphat®) in preschool children. *Community Dentistry and Oral Epidemiology, 7*(5), 241-245.

Community water fluoridation

Broffitt, B., Levy, S.M., Warren, J., & Cavanaugh, J.E. (2013). Factors associated with surface-level caries incidence in children aged 9 to 13: the Iowa Fluoride Study. *Journal of Public Health Dentistry, 73*(4), 304-310.

Hardwick, J.L., Teasdale, J., & Bloodworth, G. (1982). Caries increments over 4 years in children aged 12 at the start of water fluoridation. *British Dental Journal*, *153*(6), 217-222.

A5. Reviewed Studies Excluded from the Meta-Analyses

Resin sealants compared to no treatment

Erdogan, B., & Alaçam, T. (1987). Evaluation of a chemically polymerized pit and fissure sealant: results after 4.5 years. *Journal of Pediatric Dentistry*, 3, 11-13.

Fluoride varnish on permanent teeth

Arruda, A.O., Senthamarai, K.R., Inglehart, M.R., Rezende, C.T., & Sohn, W. (2012). Effect of 5% fluoride varnish application on caries among school children in rural Brazil: a randomized controlled trial. *Community Dentistry and Oral Epidemiology, 40*(3), 267-276.

Eck, A.A.M.J., Theuns, H.M., & Groeneveld, A. (1984). Effect of annual application of polyurethane lacquer containing silane-fluoride. *Community Dentistry and Oral Epidemiology, 12*(4), 230-232.

Gugwad, S.C., Shah, P., Lodaya, R., Bhat, C., Tandon, P., Choudhari, S., & Patil, S. (2011). Caries prevention effect of intensive application of sodium fluoride varnish in molars in children between age 6 and 7 years. *Journal of Contemporary Dental Practice, 12*(6), 408-413.

Källestål, C. (2005). The Effect of Five Years' Implementation of Caries-Preventive Methods in Swedish High-Risk Adolescents. *Caries Research, 39*(1), 20-26.

Maiwald, H. J., Künzel, W., & Weatherell, J. (1978). The use of a fluoride varnish in caries prevention. *Journal of the International Association of Dentistry for Children, 9*(2), 31-5.

Zimmer, S., Robke, F.J., & Roulet, J.F. (1999). Caries prevention with fluoride varnish in a socially deprived community. *Community Dentistry and Oral Epidemiology, 27*(2), 103-108.

Fluoride varnish on primary teeth

Lawrence, H.P., Binguis, D., Douglas, J., McKeown, L., Switzer, B., Figueiredo, R., & Laporte, A. (2008). A 2-year community-randomized controlled trial of fluoride varnish to prevent early childhood caries in Aboriginal children. *Community Dentistry and Oral Epidemiology, 36*(6), 503-16.

Slade, G.D., Bailie, R.S., Roberts-Thomson, K., Leach, A.J., Raye, I., Endean, C., ... & Morris, P. (2011). Effect of health promotion and fluoride varnish on dental caries among Australian Aboriginal children: results from a community-randomized controlled trial. *Community Dentistry and Oral Epidemiology, 39*(1), 29-43.

Weintraub, J.A., Ramos-Gomez, F., Jue, B., Shain, S., Hoover, C.I., Featherstone, J.D., & Gansky, S.A. (2006). Fluoride varnish efficacy in preventing early childhood caries. *Journal of Dental Research, 85*(2), 172-6.

Community water fluoridation

Armfield, J.M., & Spencer, A.J. (2004). Consumption of nonpublic water: implications for children's caries experience. *Community Dentistry and Oral Epidemiology*, *32*(4), 283-296.

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A6. Reviewed Studies Included in the Meta-Analyses of Different Sealant Materials

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Poly-acid modified resin composite sealants compared to resin sealants

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Resin-modified glass ionomer sealants compared to resin sealants

Amin, H.E. (2008). Clinical and antibacterial effectiveness of three different sealant materials. *Journal of Dental Hygiene, 82*(5), 1-10.

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